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CONTENTS

		PAGES
I.	Coal Carbonization and By-Products By R. N. Agashe, B.Sc., Research Scholar, D. Laxminarayan Institute of Technology, Nagpur.	1
II.	Manufacture of Laboratory Porcelain By G. T. Bhide, B. Sc.	31
III.	Manufacture of Surgical Instruments in India -- -- -- By Yakoob Khan.	57
IV.	Spectacle Frame Manufacture -- By Masood Husain.	70
V.	Manufacture of Pencil—I -- By P. S. Kapoor, B.Sc.	76
	Pencil Manufacture—II -- -- -- By S. B. Vaidya, L. M. E.	87
VI.	Ozone : Its Industrial Production and Utilisation -- -- -- By S. Krishnamurthy, B.Sc., (Hons.) Indian Meteorological Department, Poona.	93
VII.	Procedure of Mass Production of Fans, Meters and Transformers -- By S. D. Sharma, M.I.E.T., Stud. I.E.E. (London), Electrical Engineer	107

LIST OF CHARTS & ILLUSTRATIONS.

	PAGE.
Coal Distillation Products	9-10
Coking Plant Lay Out	20
Coking Plant	23-24
Double Chambered Porcelain Kiln	42
Section of the Kiln	43
Setter .	44
Artificial Muffle	46
Normal and Inverted Position of Basin and Chuck	47
Forging Furnace	59
Example of a Gauge for Surgical Instruments	62
Heat Treatment Furnace	63
Graphite Refining	79
Clay Refining	81
Winding Machine	108

PREFACE.

By the generous gift of Mr. G. D. Naidu of Coimbatore augmented by a contribution by the Industry Publishers Ltd., a Fund has been created for awarding Prizes annually to the writer of the best article on any important industry which offers possibilities of development in this country.

The subject for the 1944 competition was any industry—technical, chemical, engineering, electrical, agricultural or rural which could be started during the continuance of the war under cover of war restrictions and war necessities and could be profitably conducted after the War.

It was intended to publish them in INDUSTRY or in a book form so that the information contained in the articles would be available to the industrially minded people yearning after new ideas for new lines of business.

Owing to limited space it was not then possible to publish the articles received in response to the Prize Announcement for the 1944 Com-

petition in INDUSTRY. The most important of them are now being published in a book form for disseminaton of industrial information for the economic reconstruction of the country.

A number of copies of the book have been reserved for free distribution among the writers of the prize articles and donors to the Prize Fund.

It is intended to issue similar publications embodying the best articles received in response to Prize Competition for 1945 and subsequent years.

We only hope that these Competitions will awaken wide interest among the enlightened men of the country not because of monetary considerations alone but for the facility these offer for disseminating their hard earned experience of life for the edification of their less fortunate brethren standing in great need of industrial information to eke out an independent and honourable career.

—THE PUBLISHERS.

I

COAL CARBONIZATION AND BY-PRODUCTS

By R. N. AGASHE, B.Sc.,
Research Scholar, D. Laxminarayan Institute of Techonology, Nagpur.

INDIA produces yearly 23 million tons of coal. The chief use of coal is for the manufacture of metallurgical coke which is obtained by carbonization of coal at 1300°C. Formerly coke was produced in beehive ovens, in which air was admitted. This burnt part of the coal, carbonizing the rest. Obviously this was a wasteful process. Though the coke obtained in this way was of a good quality and was hard and porous, the yield was found to be low. The gas was subsequently used for coking, heating the furnace from below and by vertical or horizontal flues at the sides, and many economies were introduced. Hot air at 1000°C from recuperators was supplied for combustion until to-day coking requires only half of the gas, the rest being utilised in the steel furnaces, steam raising or for electrifying the neighbourhood.

BY-PRODUCTS DURING COKING.

By-products could thus be recovered but the smelters for a long time were prejudiced

against the use of by-product coke till it was proved that coke equal in quality to the beehive coke could be produced in the later ovens. To-day a not inconsiderable part of the expenses are paid by the by-products. The coke is low in ash; tar is useful for the dyestuff industry; the ammonium sulphate is used as a fertilizer and for the manufacture of ammonium salts. The tar was for long a worthless by-product to be removed somehow, and though uses were found as a liquid fuel (8500 Caloric value) and a cheap disinfecting paint, the supply greatly exceeded the demand, and it remained a matter of worry to the coke makers. The discovery of the synthesis of coal tar dyes revolutionised the whole outlook, and to-day it is a very valuable product. The manufacture of synthetic ammonia has rendered recovery of ammonia unremunerative and now it is recovered because the recovery of tar makes it obligatory. India however does not produce synthetic ammonia and the coal tar ammonia is likely to prop up the industry for many years, in view of the likely increasing demand for ammonia fertilizer. All the distillation products of coal tar (benzene, toluene, naphthalene, anthracene, phenol) are useful for dyestuffs, flavouring materials, explosives, and other chemicals.

BENZOL AND ALCOHOL.

.8 gallons per ton of coal carbonized from the 1.2 gallons of crude benzene is used as a motor fuel. India has meagre supplies of petroleum—a fraction of one per cent of the total world produc-

tion. India imports from Persia, Burma (in pre-war years) and the U. S. A. 200 million gallons to supplement her output of which 55-85 % comes from Assam and 12 % from the Punjab. Thus if it is necessary to supplement petrol any where by home-made products, viz. benzol and alcohol, it is India. In England, Germany and even the U.S.A., who produce 65% of the world's output, benzene and alcohol mixtures with petrol are encouraged and made obligatory. Home-made products there do not pay the duty on the imported petrol. In India, however, the duty of As. 10 a gallon is imposed alike on all the three, and as the price of benzol is As. 12 against As. 3 for petrol at port, it can not compete unless a preference is given to it, equally adjusting the selling prices of the three. It is for this reason that out of the to-day's potential output of benzol of 4 million gallons only 5 % is recovered, the rest being allowed to burn. India's output of iron and steel at present is 1½ million tons against 9½ million tons in England and 56 million tons in U. S. A. If this is increased, as the biggest industrialists of India including Sir M. Visweshwerayya and the authors of the 15-year plan deem necessary, to 7 million tons, the total potential output of benzol will go up to 25 million gallons. If this is supplemented by alcohol from molasses (potentiality of which to-day according to M. P. Gandhi is 15 million gallons), the imports of petrol may come down.

Apart from the economic view, benzol imparts to petrol the anti-knock property for which now

lead tetraethyl, a highly poisonous substance, is used. Benzol allows use of power alcohol with the petrol, and as power alcohol is produced from recovering crops it does not draw on the vast, though limited, supply of natural petrol which is sure to come to an end some day. Absolute alcohol alone can be used, otherwise it will separate in two layers and benzene which depresses the vapour pressure of alcohol is used to distil the last few per cents of water from alcohol. Benzene also neutralises the low calorific value of alcohol which, however, has a high thermal efficiency and so a benzol—alcohol—petrol mixture is better than an alcohol—petrol mixture. (Benzene 18000-158000 B.T.U. per gall. Petrol 2000-144000. Alcohol 11800-144000).

TOLUENE AND AMMONIUM SULPHATE.

Coke in addition to metallurgy of iron is used for copper-lead-zinc smelting and for various heating purposes. The reserves of Indian good coking coal are estimated at 1,500,000,000 tons from Giridih, Ranigunj, Jharia, Bakarao and Karanpura. The toluene is used for T. N. T. The ammonium sulphate is a very useful nitrogenous mannure. The soil of India is very poor in nitrogen and phosphorus due to the long continued exhaustion of the soil. Without proper application of manures the acreage of India will dwindle still further and tillage will pay less. The 25 lbs. of ammonia from one ton of coal carbonized will be much helpful in this matter.

SYNTHETIC RESINS, PERFUMES, ETC.

Synthetic resins are gaining more and more ground every day and 75 % of the 120,000 tons produced to-day are from phenol or urea-formaldehyde or cumerone resins from naphtha, another coal-tar distillation product. Several other products are obtained from coal tar products, chief of them being perfumes like methyl salicylate (wintergreen), benzaldehyde (almonds), vanillin, artificial musk, and a host of others. Saccharine, 500 times sweeter than sugar, is prepared from toluene. Antiseptics like phenol, lysol, aspirin, salicylic acid are made from phenol. A large number of photographic chemicals and medicines are also prepared from tar distillation products. The industry is thus an all-important one.

INDUSTRIAL BACK-GROUND FOR SUCCESS.

It must be borne in mind that for any one industry to prosper, the general industrial activity of the nation as a whole must improve. No single industry can reach its peak in a Crusoe Island, and hence in this article it has been assumed that a general industrial growth of India takes place side by side. There will be an well-established heavy chemical industry to supply the necessary sulphuric acid, hydrochloric acid, nitric acid, caustic soda, ammonia, chlorine, bromine, sodium-hyposulphite, phosphoric oxide, ethyl alcohol, methyl alcohol, acetic acid and others. There will be plants to absorb the various by-products for further processing. There will be a large skilful literate class for the industry to draw her skilled

workers from. There will remain a government sympathetic to her wants, and an understanding public to help her. The literate, progressive and prosperous peasants will buy fertilizers and other products. There will be a railway board with the country's good at heart and will arrange the railway tariff which will help the home industries grow and not as at present to encourage export of raw materials and import of finished products. There will be capitalists who will rely on their technologists and be interested in the ultimate good and not their immediate 3½ % of profit. They will encourage technical research and not go simply by the trodden path. The engineers will fit up machinery not on the lowest quotation basis but with efficiency in view, and scrap any piece as soon as it falls short, and not wait for it to break down. They will plan the outlay with future expansions in view. The experts will be chosen on merit only and not from the 'also ran' class on lowest pay acceptable terms. Research is all important. The Fuel Research Board of London is spending £ 90,000 a year. Every industry must be ahead of the world or perish. In up-to-date large scale production lies India's salvation.

CARBONIZATION PLANTS IN INDIA.

The first coal carbonization plant in India was built at Giridih, for the E. I. Ry. This has been rapidly followed by others. They are now producing 300 tons per day by the Simon Carves ovens of which 50 are working. Others were

built at Lodna, Loyabad, Jamshedpur, Bararee, Bhowra, Kulti, Hirapur of which the Tatas alone are making 2 out of the total of 4 million tons of Indian production. The silica and other refractory materials produced in India are found to be equal to the best foreign product. The Tatas are the largest single plant in the Empire. They have the Coppee-Koppers-Wilputte ovens. The 54 Simon Carves ovens erected in 1936 at a cost of Rs. 70,00,000 produce 1,560 tons a day which may be increased to 4,800 tons per day with recovery of by-products. The Indian Iron & Steel Co. and the Bengal Iron Co. have Simon Carves ovens. The Jharia and some other Bihar coals give excellent coke with a rather high ash (15-20 %) which however is compensated by the extra purity of Indian Iron ore which would otherwise require more limestone (low in sulphur, 5 %, and often low in phosphorus also) which renders it well-suited for ferro-manganese of which ½ million tons are produced in India.

COAL DISTILLATION PRODUCTS.

The industry is a huge one and only the briefest sketch can be presented within the scope of this article. The chart on page 9 shows the different products obtainable from 1 ton of Jharia coal.

CHARGING AND DISCHARGING COAL.

The proper quality of coal must be selected and ground below 6 m.m. Older fossils give aromatic hydrocarbons which are useful for dye-

stuff industry, even a small percentage of aliphatic hydrocarbons in the tar renders it unfit. In the modern plant 50 % anthracene can be used which in the beehive ovens was useless and hence the world's supply of coking coal has been supplemented.

The grinding of coal is usually done underground, and mixed thoroughly by a system of rubber belts and conveyed to the hoppers by a coal charging lorry to which it is charged through chutes in the coal bunker. The lorry has 4 hoppers, 8 charge holes, fitted with a mechanically operating charging gear, poking holes, etc. The charge is mechanically weighed before travelling. The whole requires 30 H.P. The previous charge is discharged by a combined door extractor, coal pusher, leveller machine, weighing about 100 tons mounted on 8 wheels and pushes coal at 90 ft. per minute. The rope operated coal levelling bar is provided with observer's car and the new charge is put in. The discharged material is received in a combined coke guide and door extractor and the car, which moves slowly as it is filled to have the coke level, is steamed under a quenching house where 6,000 gallons of water are dropped on it, of which 1,000 gallons are evaporated. The car is drawn out, allowed to steam for 1 minute, and loaded on the warp, from where it is conveyed to the screens on rubber belts. Grizly or flat vibratory screens are used and coke about 2″ size is sent to the blast furnace. Bigger pieces have to be cut by Cortes or Nelson cutters of a capacity of 30 to 50 tons per hour.

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--- the first tower. Cooling with water requires 5

tons per day per oven. The tar is extracted in centrifugal extractors, centrifugal fans running at 500 R. P. M. on which water is sprayed. The tar forms globules as it strikes the blades and walls and flows down. Simply cooling does not precipitate the whole of the tar as it forms a mist similar to the sulphuric acid mist in lead chambers. It is often precipitated by subjecting it to a high tension pulsating direct current, produced by an A. C. Converter. The gases are allowed to enter the apparatus just below the tube plate in which several tubes are expanded. The gases first pass down and then up through the lower open ends of the tubes, then outside. 15 K. W. per million cu. ft. of gas are consumed separating 95 % of the tar fog. The ammonia which does not separate by cooling as ammoniacal liquor is absorbed by scrubbing with a neutral solution of ammonium sulphate. The alkaline solution flowing out is acidified with sulphuric acid and the solution pumped for recirculation. When of 1.2 specific gravity some of it is removed and crystallised. The hot gases are scrubbed with sulphuric acid thus absorbing ammonia and cooling the gases in the direct process. The heat of the gases serves to concentrate the solution here, whereas direct scrubbing with water gives a large volume of effluent which cannot be disposed off easily. The fuel cost is high for concentration of the ammonical solutions and for steaming and liming. The amonical liquor and the sulphate are steamed and limed to get ammonia, which is converted into liquid ammonia, ammo-

nium salts, and liquor ammonia variously used. The chief uses are as a fertilizer, in the ammonia soda process, (which now produces all the soda ash of the world having completely displaced the Lc Blank's process), manufacture of nitric acid by oxidation and the manufacture of urea, used in the urea-aldehyde synthetic resins industry. The gases are finally cooled by spraying water on a worm carrying the gases.

PRODUCTS FROM THE GASES.

The gas contains 20 times the weight of benzol from tar from the same amount of coal. It is scrubbed with creosote or petroleum oils. The absorbtion of the vapours depends on the temperature of the oils, and artificial refrigeration does not pay. Ultimately the amount absorbed depends on the atmospheric temperature, and as it is generally high in India the yield of benzol is low, and the benzol recovered contains more high boiling toluol and xylenes, some of the volatile benzene passing with the gas. Oil at 15°C is sprayed in large towers meeting the rising gas counter-current-wise. The percentage of water in the oil must not be above 1 %. The benzolized oil is steamed at 115°C. The vapours from the debenzolizing still are used to preheat the incoming benzolized oil. The distillate contains 10 % of the oil. The oil and crude benzole are distilled and the distillate washed with sulphuric acid, soda and water. 3,000 gallons of benzol require 1,300 lbs. of 160 Tw. sulphuric acid, 125-215 lbs. sodium carbonate and 28 to 45 lbs.

caustic soda. The benzol is washed with portions of the acid with agitation followed by separation in conical-bottom vertical stills. The washings with soda are slowly agitated, otherwise emulsification occurs. The washed benzol is rectified and fractionated into its constituents. Benzol is otherwise absorbed with activated carbon or silica gels, the absorbent being cooled while processing. Carbon is reactivated by steaming at red heat. The toluene forms an important factor in national defence in form of T. N. T. (Tri Nitro Toluene), and purchases made by the Government would support the industry. The debenzolized oil is used over again as many as 20 times and before burning, using for pickling timber or for prepared tar which is treated for recovery of naphthalene. The permanent spare gas can be used for the manufacture of motor spirit, or as a source of hydrogen for the manufacture of ammonia, hydrogenated oils, etc.

TAR.

The most important by-product is the tar. Tar is used as a paint, manufacture of illuminating gas, obtained by destructive distillation. I gallon of tar gives 50 cu. ft. of 50 candle gas —soot, felt, etc., for impregnating brick and stone in acid houses. At present, however, it is largely distilled in sheet iron stills with a concave bottom, protected by fire-brick arch, and a cast iron dome, as cast iron stands the hot vapours better. The tar is dried in a pre-heater, heated by the vapours of the primary still, which are themselves cooled.

The dry tar is added to the empty, not too hot, still. Open steam coils are also fitted to prevent coking of the tar and choking of the coil by anthracene green grease. The condensing coil is cooled by water in an iron tank and the uppermost coil includes a steam pipe to avoid choking by naphthalene and anthracene. The water in the tank can be heated by a steam coil.

FRACTIONS OF TAR DISTILLATION.

The fractions are separately collected as :

*(1) Light oil or (1 a) first fractions and (1 b) light oil at 170°C.
(2) Middle or carbolic oil at 170-230°C.
(3) Heavy or creosote oil at 230-270°C.
(4) Anthracene or green oil at 270-360°C.
(5) Pitch at above 360°C.

The first fraction separates into ammoniacal liquor and light oil and are treated as such :

Each distiller separates his fractions according to his needs, the criterion being the temperature, specific gravity of the products, appearance of the distilling still, smell, etc. variously. Cold water is used for condensing the light oil. It is allowed to get warmer for the middle oil by regulating the flow, hotter for creosote oil by stopping it, while it is actually heated by steam for the last fraction. Thus the crystallization of naphthalene in the worm is avoided. The still is fitted with safety valves, thermometer and other instruments, discharge pipe, etc. The distillation is ended by

*1 is German practice; (1 a) and (1 b) are American practice.

blowing in steam. A vacuum is often employed, which lowers the distillation temperature and gives purer distillates. Often before running the pitch out, creosote oil is pumped in the still and mixed with the pitch making ' Prepared Tar ' used as a paint. This lowers the temperature of the pitch and the fire hazard is lessened. The pitch is run under a layer of cold pitch so that it does not come in contact with air when hot. The steam helps to drive away the anthracene vapours which are heavy and would collect in the still itself.

LIGHT OIL.

The light oil contains 60 % oils of the benzene series, 20 % naphthalene series, 5 to 15 % carbolic acid and cresols with pyridine bases, etc. The light oils are fractionated in stills 2 m. × 2 m. holding 750 gallons, with a lead cooling worm cooled by water, first cold and as the temperature goes above 170°C. by warm, to avoid choking due to naphthalene. The still is mounted with dephlegmeters 1 m. dia. × 4 m. high. The first fraction is collected up to 135°C, specific gravity ·89 as crude benzol; second up to 165°C. specific gravity .95 as benzol II or heavy benzol; third up to 200°C, specific gravity 1, carbolic oil. The residue contains naphthalene and is worked with the middle oil. The heavy benzol is again fractionated into light benzol and solvent naphtha at 160-190°C, which is washed with 1 to 3 % sulphuric acid. The residue is cooled to get naphthalene. The soda washings are acidified with

sulphuric acid or carbon dioxide and carbolic acid is obtained. The acid washings are diluted and neutralized with ammonia to get the pyridine bases used for denaturing spirit. The tarry matter is used with rubber to give an insulating composition or dissolved in petroleum spirit to form a varnish. The pyridine bases are used for refining anthracene, dyestuffs, disinfectant manufacture, etc.

MIDDLE OIL.

The middle oil contains naphthalene 40 %, phenols 25-30 %. (10 % carbolic acid and 90 % cresols), 5 % bases like pyridine, etc. On cooling much of the naphthalene crystallizes and separates, is filtered and distilled using an appropriate column. The remaining oils are treated with alkali and acid to get the phenols and the bases. Often the oil is distilled without separating the naphthalene into crude benzol, phenol fraction up to 195°C., naphthalene oil up to 220°C., containing 40% naphthalene, 40% acids and 7% bases, which are further fractionated. The residual oil is used for washing benzene vapour from coal gas.

CREOSOTE OIL.

The creosote oil after separation of naphthalene was used for burning, pickling wood, manufacture of lampblack, etc. It is now distilled into naphthalene oil I and II up to 230° and 280°C, respectively and a residue to be worked with anthracene oil. The naphthalene oils are

cooled to separate the naphthalene, and the first oil washed to get bases and phenols (25 %) and the second fraction used for pickling timber. The residue is often used for the manufacture of prepared tar, soot, fuel or for pickling.

COKE OVEN TAR.

Coke oven tar contains .75 % of pure anthracene forming 2½ to 3% of the oil, from which it deposits in crystals. In hot climates it needs artificial cooling to 15°C. in shallow iron pans 45 cm. deep. The crystals are filtered in filter bags, filter presses, cage or plate Anglo-American presses, centrifugals, etc. The oil running out is mixed with creosote oil for pickling timber, making prepared tar, or used as a lubricant, or is again distilled and fractionated to get more anthracene. It is also used to scrub out naphthalene from coal gas. The crude anthracene is washed with solvent naphtha, petroleum spirit, creosote oil, etc. and cooled to 20°C and the anthracene dehydrated and sublimed to get the pure product. It is used for the manufacture of alizarine and other dyestuffs.

PITCH.

The pitch from the still is used for caulking seams of boats, road making, terraces, roofing felts, water proofing, etc. The length of tarred roads in India has multiplied 6 times during the last 5 years and there is likely to be a big demand for it in future. Briquettes are made with 5-10 % pitch. Pitch is also used in the form of prepared

tar for paint, preparing waterproof paper pipes, sand moulded articles, which are proof against acids, alkalies, etc. and for the manufacture of ultramarine, lampblack, etc. A layout of a coal distillation by-products plant is reproduced here.

CONSIDERATIONS FOR MAKING A START.

The primary point in the location of a plant is 'minimum cost' in the broadest sense of the word, giving the best remuneration on the outlay, i.e., best type of oven with the optimum length, width and height for getting best coke out of the coal available. The quality of the coke as well as the tar depends on the size of the furnace, charge of coal and even the shape of the oven. If the gases are quickly removed from the oven by an exhauster, more hydrocarbons of the aromatic series are produced. A thick bed subjects the inner portions of the bed to slow distillation due to the non-conducting outer layer of coal and consequently tar containing aliphatic compounds, quite useless for dyestuff manufacture, is produced. Accurate control with reliable controlling apparatus like thermometers, recording or indicating pyrometers, pressure gauges, draught gauges, hydrometers, etc. must be fitted at various points in the apparatus, too numourous even to mention. All precautions against fire must be taken. Buildings must be as far as possible fire-proof. Safety valves must be fitted. An up-to-date chemical laboratory for checking and controlling the process must be mentioned, with a really efficient personnel at work. This branch has uptill now been

COKING PLANT LAY OUT.

grossly neglected by Indian manufacturers and the sooner it is rectified the better. The coal proposed to be used should be coked in existing furnaces to determine what type of ovens and method of working is best suited for the coal. The money spent over that will amply repay itself. The foundation of the heavy structure with its immense heat and load must first be sought by drilling to avoid subsidence. Strongest foundation is needed for the coke ovens especially. The siding should slope from the coal to the coke bunker so that waggons can be hand-shunted when empty. The coke should be pushed to the opposite side to where the by-products plant is situated.

ARRANGEMENT OF DEPARTMENTS.

Abundant water should be available and an inland pump for drainage of offensive liquids. Coal should be at hand as well as a blast furnace. The grinding and mixing should be done underground as at the Tatas. Good road and railway connections are necessary. The exhausters, pumps, compressors, sulphate centrifugals can all be enclosed in one building, sulphate store being next door. Benzol building must be separate. Tiled walls and tiled sloping floors are necessary everywhere. Cooling and condensing plant should be 25 % above margin.

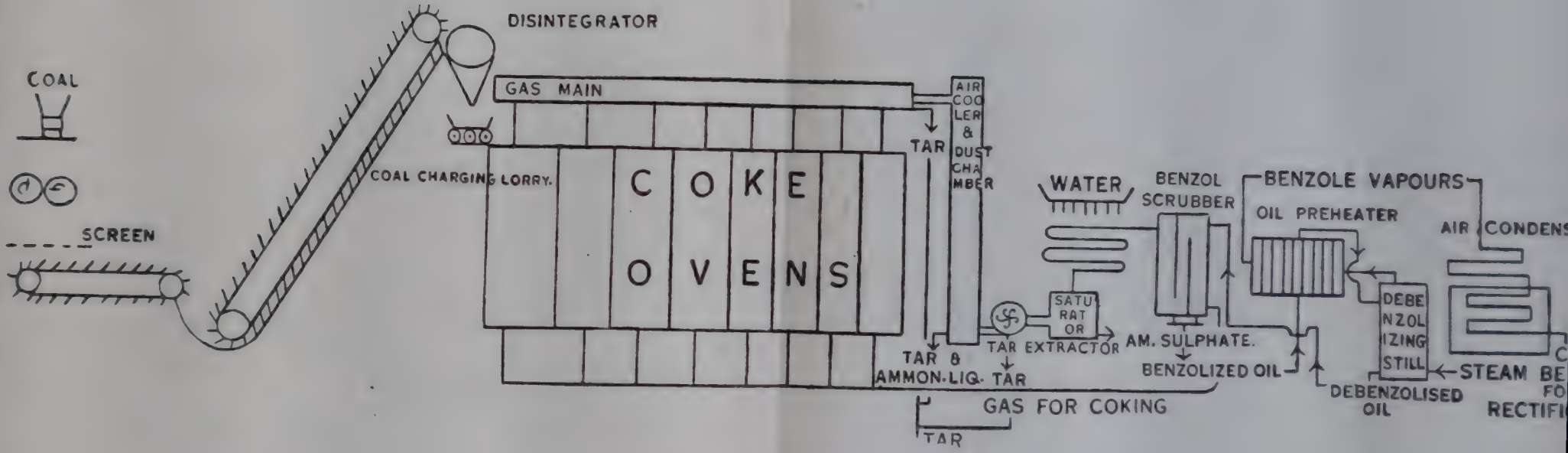
FIRING THE FURNACE.

The firing of the furnace must be well controlled. The silica bricks expand 1.3 % from 100° to 600°C, mostly between 150° to 250°C.

The heating must not exceed 5°C per day. After 600°C upto 1000°C it may be 10°C per day. The rate may increase after that. The tie rods binding the furnaces must be loosened from time to time to compensate for the expansion of the brick-work. The heating is done with coke or producer gas in the oven proper. With all the foregoing much remains to be described about the layout, etc. and in fact after all that can be written much remains to be experienced and only experienced hands should attempt firing a furnace, otherwise a break-down is sure to follow.

PROSPECTS.

No industry is easy to start and work during war or peace time, and no industry can be started and worked if there is not sufficient initiative in the capitalist and the technologist. This industry is no exception to this rule. The industry is not new to India and the necessary technicians and skilled workmen are at hand who may train more men to the trade. The co-operation required for this is not lacking among industrialists of the new awakened India. About the obtaining of the necessary priorities for the heavy machinery, the Government of India are quite eager, at least due to the war pressure to replace as much petrol by home products as possible and can be prevailed upon to leave their conservative policy. They are also in need of toluol for explosives and attempts at production of this all important material are likely to be encouraged in today's difficult times, if at all. Other chemicals are no less important



Coking Plant.

for the explosive industry. Thus all the by-products will be for the present absorbed by the Government.

If this industry is started the coking, tar distilling and dyestuffs industry will have to be built in one breath. Otherwise, the by-products will not be easily absorbed. We can split the great work in two, coking and tar distillation, and dyestuffs. The by-products between the two steps are in urgent demand and there is no fear of exceeding the demand for the present. The purchase of by-products will be continued for some years after the war by the Government and the starting of other industries, heavy and fine, will get enough time to stand on a firm foundation. So, if at all, this is the time to start this all important industry. Moreover, the portion of the machinery to be obtained from abroad is small when compared with the huge structures which could be engineered by home sheet steel, which is near at hand and need not wait for sufficient transport facilities to be brought from afar. The fire bricks are available near at hand and have proved to be of the best quality. The iron and steel structure is not far to seek. All other materials are easily obtainable. Thus for this particular industry war may be said to be a boon, not hindering supply of raw materials for the initial lay-out and offering huge market for all the by-products. Indian coke to-day will be very easily absorbed by the steel works to their mutual advantage, and the demand today is unlimited and shows definite signs of increasing even after the

war. Thus the war should not offer insurmountable difficulties, though difficulties there will of course be, but difficulties need not hinder progress, *Per Adna, Ad Astra.*

IMPORTS OF DYESTUFFS, ETC.

Some idea about the vastness of the industry of dyestuffs may be gained from the figures below of imports in India in the year 1938-39, the last pre-war year of normal trade activity :—

	in 1000 lbs.	in 1000 rupees
Alazarine dry	3	7
„ moist	871	562
Congo red	474	254
Naphthols	916	23,40
Rapid fast colours	147	896
Bases	495	10,31
Other Salts	1,016	17,29
Indigo	698	10,09
Carbazole blue	85	2,04
Other vat dyes	974	1,15,36
Sulphur black	2638	576
Metanil yellow	203	194
Auramine	—	—
Rhodamine	—	—
Aniline Salts	244	81
Other dyes	3288	56,95
Saccharin	28	83

The imports of dyes during the three years ending 1937-38 are given on the next page.

IMPORTS OF COAL TAR DYES.

	1935-36		1936-37		1937-38	
	in 1,000 lbs.	in Rs. 1,000	in 1,000 lbs.	in Rs. 1,000	in 1,000 lbs.	in Rs. 1,000
Alizarine below 40 %	9	16	9	16	4	7
„ above 40 %	7	18	11	31	9	25
„ moist below 16 %	141	75	279	1,39	182	86
„ „ 16-20 %	1,891	11,46	2,023	11,71	1,760	9,48
„ above 20 %	258	3,31	225	2,70	305	3,14
Congo red	2,577	14,59	2,483	13,55	2,106	11,37
Naphthols	977	26,23	753	21,05	1,354	30,61
Rapid fast colours	60	1,322	52	2,79	88	5,04
Bases	565	12,09	390	8,17	777	16,70
Other salts	1,002	14,27	861	12,87	1,173	18,38
Indigo	1,213	16,93	800	10,59	905	12,68
Carbazole blue	80	1,67	86	1,85	145	3,24
Other sorts paste	216	5,25	170	5,18	177	7,65
powder	610	89,28	671	95,46	785	1,21,35
Sulphur black	4,359	11,86	3,143	6,76	4,759	9,81
Metalnil yellow	755	6,98	877	6,72	814	6,68

	1935-36		1936-37		1937-38	
	in 1,000 lbs.	in Rs. 1,000	in 1,000 lbs.	in Rs. 1,000	in 1,000 lbs.	in Rs. 1,000
Auramin below 15 %	16	24	—	—	—	—
Rhodamins	3	8	2	6	—	—
Aniline salts	241	90	300	1,15	374	1,34
Others	5,469	84,21	3,814	58,43	5,164	84,10
Saccharine	91	3,82	23	74	25	86

IMPORTS OF COAL TAR DYES BY COUNTRIES IN INDIA.

	1935-36		1936-37		1937-38	
	in 1,000 lbs.	in Rs. 1,000	in 1,000 lbs.	in Rs. 1,000	in 1,000 lbs.	in Rs. 1,000
U. K.	2,184	41,58	11,668	1,79,01	14,946	2,50,59
Germany	13,768	2,00,94	1,775	36,51	2,193	36,92
Switzerland	670	19,87	456	15,59	653	20,37
Japan	1,404	12,33	1,156	10,67	990	9,55
U. S. A.	1,427	14,24	791	7,63	762	7,97
Others	992	1,44	1,104	11,52	1,343	15,35
Total	20,447	3,03,37	16,944	2,60,94	20,888	3,42,76

INITIAL EXPENDITURE.

The initial expenditure for a plant coking 3,000 tons daily and distilling the tar is estimated to be near about 2 crores and it is not difficult to obtain that if the capitalists and technicians trust each other. There are technicians in India who worked the plants quite efficiently. The plant is mostly worked automatically with comparatively few skilled workers. Coal at Rs. 4 a ton when converted into coke at Rs. 30 a ton leaves a good margin of profits and the by-products, valuable as they are, remain as net profits. One eminent expert who has worked a plant for the last 30 years opines that with good management the profits should be between 35 to 72 % on the outlay. The excess of outlay required by the war conditions will be more than counterbalanced by the war profits and above all by the footing which the industry will get when normal times with their keen competition return.

This article has been very brief and an attempt is made at covering the most important aspects of the industry and is not intended to guide the technician. There are volumes, written and unwritten, that will have to be consulted by them. This article intends only to arouse the enthusiasm of the layman and the writer will be satisfied if it is attained even to a limited extent, and will be glad to receive constructive criticism on the information given and stands subject to correction, omissions and commissions by those who are better authorised to opine about the subject.

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AN ERRATUM

Page 7, Line 18 for *5 per cent.* read *5 per cent.*

II

MANUFACTURE OF LABORATORY PORCELAIN.

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"If the clock's ticking of its minutes does not stimulate the weary, lazy or ambitionless man to accomplishments, the rolling year will ultimately overtake him while he is yet empty handed." (*Dr. Frank*).

INTRODUCTORY.

Laboratory porcelain occupies a very important place in the machinery of scientific education. If we dare imagine that there was no chemical porcelain at all, the educational machinery would go out of gear. Platinum crucibles and dishes can replace porcelain ones. But the cost of one porcelain crucible will be a rupee and that of platinum a hundred times that much. The net result would be that only the rich few would be able to procure their requirements.

Under the term 'laboratory porcelain' is included all porcelain ware, made to resist the combined action of heat and acids, such as evaporating basins, crucibles, etc. The absolute heat conductivity of chemical porcelain is greater than that of glass, but co-efficient of expansion is less than that of ordinary glass or stone ware.

Great progress has been made in the manufacture of laboratory porcelain during the past two decades, the result of which has been that French refractory porcelain has been largely replaced by German ware. Indeed in Germany the manufacture reached so much success, and price became so very reasonable that the production of this ware remained confined mainly to that country. Since 1916 it has also been made in Great Britain. Japan too did not lag much behind. It is regrettable that India only has been conspicuous in lagging behind in all industries including the manufacture of porcelain. Even as late as 1942 no factory in India was producing this type of porcelain. Now as far as knowledge of the author goes, factories at Bangalore, Than and Nagpur have undertaken the manufacture of this type of porcelain ware.

GENERAL COMPOSITION.

Porcelain is regarded as the noblest in all the pottery wares. The term "Porcelain" embodies a certain class of pottery having a vitrified white body exhibiting translucency and a white glaze which has peculiar softness quite unlike other specimens of pottery. Chemical porcelain differs from ordinary porcelain in possessing some specific properties which have been mentioned below.

It has been found that porcelain containing less than 15 % of Felspar and from 40 to 50 % of clay is the least sensitive to sudden changes of temperature.

The refactoriness of this porcelain is at its maximum, when the proportion of alumina is high and of felspar low. In most instances the undermentioned compositions can be roughly used.

	I	II	III	IV
Beauvoir Kaolin	50	—	—	—
St. Yrieix	20	21	—	—
English China clay	—	43	60	49
Sand	10	16	22	25
Felspar	10	10	15	26
Chalk	3	4	3	—
Broken Porcelain	7	—	—	—
Steatite	—	—	—	0.5
Iron oxide	—	—	—	1.0

Introduction of sillimanite or talc at the cost of quartz reduces the free quartz crystals in the fired body which will minimise the chances of cracking on repeated heating and cooling of the ware. Alkalies have lower heat conductivity and higher thermal expansion values than lime and magnesia. Hence chemical porcelain should have as low alkali content as possible.

RAW MATERIALS.

The chief raw materials that constitute chemical porcelain are as follows:

CHINA CLAY.

This clay was known in China as Kaolin by which they meant a white plastic earth used in the preparation of white porcelain bodies. Bihar which is known as Staffordshire of India abounds in this clay. The other provinces in which it is

sporadically found are U. P., Assam, Bengal, C.P. and Bombay. The function of China Clay in body corresponds with the function of skin in human body.

QUARTZ.

Quartz is nothing but another form of silica found in nature. It gives strength to the body just as bones do in human constitution. It is found in India in various places.

FELSPAR.

Felspar is the clay name for a group of related materials. Their general formula is

$$\left.\begin{matrix} K_2O \\ Na_2O \\ CaO \end{matrix}\right\} \; Al_2O_3 \; 6 \; SiO_2$$

Generally potash felspar is used in pottery.

WHITING.

Whiting is nothing but precipitated pure chalk or $CaCO_3$. It is found in abundant quantities in C. P. and Punjab.

GYPSUM.

Gypsum is used in the preparation of plaster moulds. General formula is $CaSO_4\ 2H_2O$. It is found in India, in the Punjab and Central Provinces.

PREPARATION OF THE RAW MATERIAL.

Purification of the Clay—China clay usually occurs mixed up with gravel, small stones and other foreign matters which cannot be picked out by hand. They must be washed out or screened according to the nature of the impurities to be removed. Some clay workers urge that washing

of the clay is more economical than pugging and screening as less power is required and the product is superior. But the relative efficiency of the methods must necessarily depend upon the type of clay and the purpose for which it is to be used. There are various methods for purification and washing of the clay. One crude method is as follows.

The clay is powdered and is made into a paste with water. It is then thoroughly blunged by hand and allowed to settle. The heavier particles like sand will deposit at the bottom and the clay water is carefully poured into another basin. There again it is allowed to settle for a little time. Again a little sand will be deposited. Clay water is again poured out. This clay water contains pure china clay. A detailed description of washing and purification appliances is given in "Clay Workers' Hand Book" by Searle.

Other materials like felspar, quartz, whiting do not need purification. They are powdered in ball mill which is nothing but a cylinder lined with vitrified bricks. This is rotated through some external agency. It contains flint balls which do both grinding and powdering. The materials thus powdered are then sieved through 200 mesh and is sent to drying shade.

MACHINERY.

The following are the essential machineries for the manufacture of Laboratory porcelain.

I. Blunger.

II. Membrane Pump.

III. Filter-press.
IV. Edgerunner-Mill.
V. Pug-Mill.
VI. Electric Motor or Oil Engine.

MANUFACTURE.

The manufacture of chemical porcelain calls for a very careful attention from the beginning to the end. The term 'laboratory porcelain' embraces many things but the author proposes here to deal with crucibles and evaporating dishes only in detail.

FACTORY PREMISES.

The author has already stated in the previous paragraph that careful attention is essential from beginning and so it does begin from the manufacturing hall. The floor of the room should be either tiled or made of concrete which should be cleaned properly before the commencement of the factory. Dust is a problem in other industries and that devil is making itself felt in this industry too. A little allowance for it and the whole charge is spoilt in no time. The workers should be told to keep their shoes outside and come in with washed feet. The room should be properly ventilated but should prevent ingress of any outside dust. The windows should be provided with glass panes to prevent outside interference of anything except light. The doors should have springs. False economy is most unwise and unpaying here.

The composition should be weighed out carefully in either wooden or enamelled *gyamelas* (Big hollow wares). Iron vessels should not be

used under any circumstances as the stains of iron oxide appear in the fired articles. Then they are blunged for a specified time after adding Na_2CO_3 and Na_2SiO_3 to it. Afterwards it is sieved and slip is now ready for casting.

CASTING.

Casting is done in Plaster of Paris moulds. The preparation is simple. A wooden model of the article of which the mould is to be made is prepared. It is then lightly surrounded by tin sheet and Plaster of Paris of proper consistency poured in it.

It is then allowed to settle for 20 minutes and the tin sheet is later removed. The mould is then allowed to dry for two or three days and is then ready for casting. The thickness of the crucible and the evaporating dish is maintained by keeping the density and time constant. The density is determined by hydrometer and the same density is maintained everytime the charge is weighed out. The workman is then told to fill up a particular number of moulds in one round and pour them off, as soon as the number is reached. If one more or less mould is filled, the thickness at once changes. In this way when all the moulds are filled, excess of clay is wiped out and the mould is allowed to dry. When the article is released from all the sides, the mould is inverted, and the article sent to drying shades. In this process one thing should be remembered that the article should never be released with a force. Some workmen have got the bad habit of stroking

the moulds. If the article is not freed from all the sides this will deform the ware. This deformed ware is never accepted in the market.

CASTING WITH JIGGER AND JOLLEY.

Another process by which it is possible but not practicable is that of Jigger and Jolley. A wooden template or profile of the required shape is prepared. This is fixed in the jolley and plaster moulds of the same shape are fixed in the jigger. Later on the template is adjusted according to the thickness and the instrument is ready for working.

The clay required for this process has to undergo some more stages than mentioned above. The slip which is the technical name of the liquid clay is then transferred to filter press, the function of which is to remove excess of water. This pressed clay contains several air bubbles which will harm the article in the ultimate firing. Therefore it is pugged in Pug-mill and then small lumps are prepared. These balls are then thrown into the hollow portion of the mould with a force and the clay is uniformly spread by skilful movements of the fingers. Later on the Jolley is brought down, the excess clay is wiped out, and the mould is taken out and allowed to dry.

This process entails more skilled labour than the previous one. Moreover the fixing of the profile involves a lot of trouble and wastage of time which of course can be curtailed after a prolonged practice. Moreover a careful watch will

have to be kept to maintain the, thickness. The profile if it is wooden wears out in course of time. So it has to be replaced. Sometimes the position of profile also changes and ware of unequal thickness is the result. For vast production in a most efficient manner the under-mentioned process is the most useful. It requires less skilled labour and there are less chances of breakage during transit or preparation.

PRESSING.

There are two methods of pressing:—(1) Mechanical Pressing and (2) Hand pressing.

The pictures of the mechanical and hand press will be found in the book named 'Refractory Material' by Searle. The clay to be pressed requires more treatment than the jolleyed one. The filter pressed cakes are dried in special hot rooms and then powdered in *disintegrating* mill. This powder is mixed with water and oil and made into such consistency that when a lump is pressed no water should ooze out but the shape should be retained. This clay is passed through kneading machine to mix it uniformly and to drive out the air bubbles. Small lumps are then made and kept in the die and the punch brought down with a force. This will spread the clay uniformly and a neat crucible will be formed. The fly wheel is then raised a bit up and another powerful jerk is given. This will finally remove the entagled air if any. The crucible is then taken out and sent out to drying shade.

The oil used for the purpose is Rock-oil and Linseed oil mixed in equal proportion. 300 lbs. of dry powder is mixed with 4½ litres of oil.

DRYING.

The method of drying deserves a little attention. The articles to be dried are not to be kept near a very hot surface, else the article may crack. A slow heating process in an airy room is the proper method. There are two methods of drying: (1) keeping the articles on wooden shelves in an airy place and (2) keeping them in heating chamber either heated by exhaust steam or by inserting fire beneath the room.

The first is the cheap method which a newly started factory can easily adopt but it has got its disadvantages also. This method is useful in summer only as the atmosphere is dry. In winter and in rainy season the results are unsatisfactory because of the difficulty of drying. Moreover since the articles are kept in the open, breakage might be high.

In the second process a closed chamber is fitted with steam pipes. The steam is brought from engine exhaust. The wooden shelves are arranged in the chamber with sufficient space for a workman to pass through. Arrangement for air to come in is kept at the bottom. A screw is fitted at the top. The function of the screw is to drive out the hot saturated air, (saturated with water vapour). The place of it will be taken by unsaturated cold air which will become hot on coming in contact with steam pipes. In this way

the convection currents will be created and the articles will be dried slowly, without any crack developing.

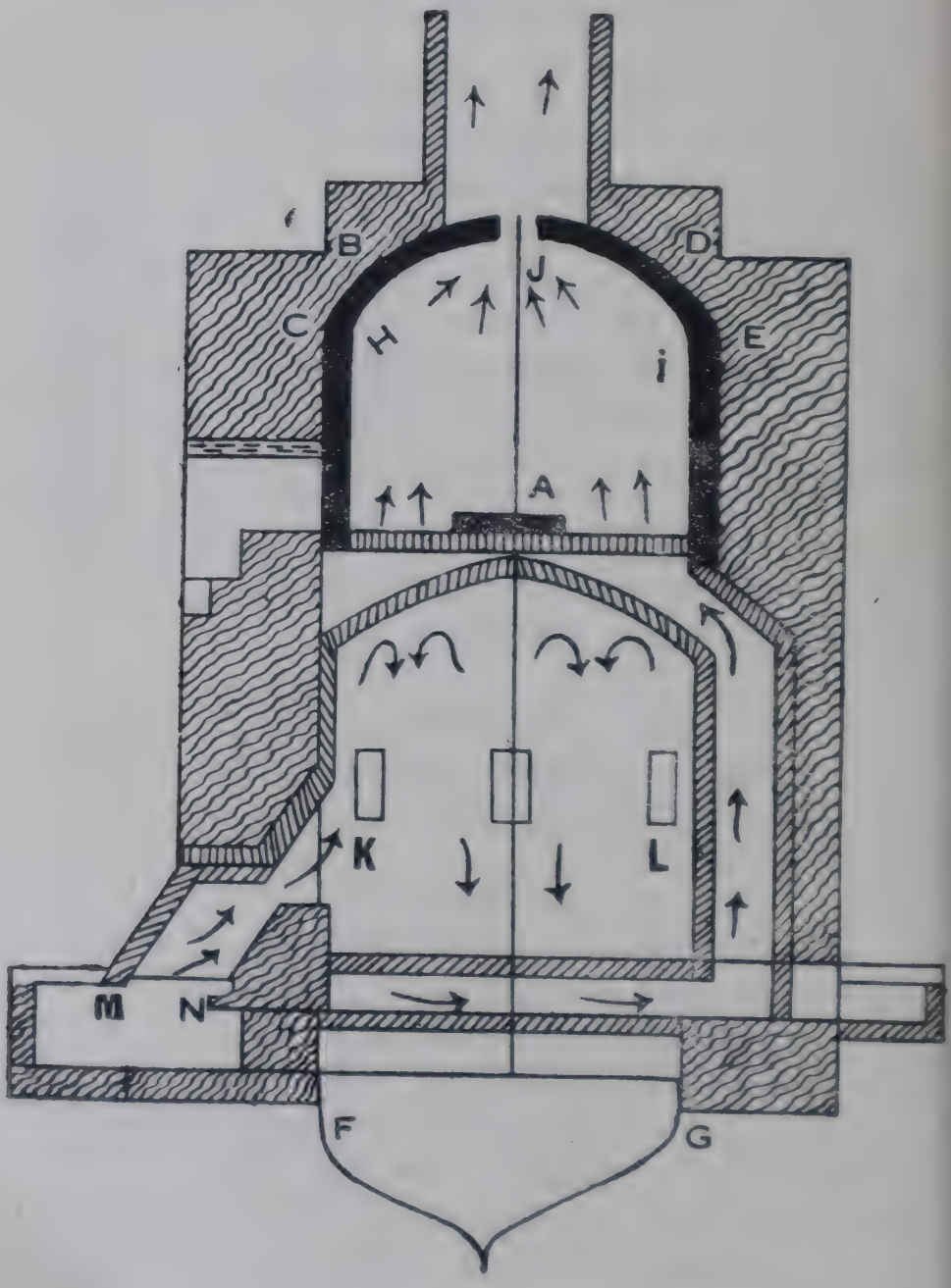
In the second process, fire is kept beneath the floor and due to ordinary ventilators the articles are dried. The temperature of the room is always kept between 20° to 25°C. Moreover the author has noted one thing which should be marked carefully by every manufacturer viz., that 10% breakage occurs due to rough and unnecessary handling. So the less handling, the less breakage. If drawer-like arrangements are made in the shelf, handling will be reduced by at least two times showing corresponding decrease in breakage. The temperature of the drier should not be more than 25°C and not less than 20°C.

BURNING.

Burning is divided into two stages:—(A) Biscuiting and (B) Glazing.

BISCUITING.

The process of burning the article to such a stage that they will tolerate rough handling but will not dissolve in water is known as biscuiting and the articles are known as biscuited articles. Laboratory Porcelain is a very delicate thing and cannot even withstand slight rough handling. So difficulty arises about cleaning. This is solved by first biscuiting the articles and later cleaning by sand paper. (The method of cleaning will be described later on). The temperature used for biscuiting is also of importance. A cone of 07A

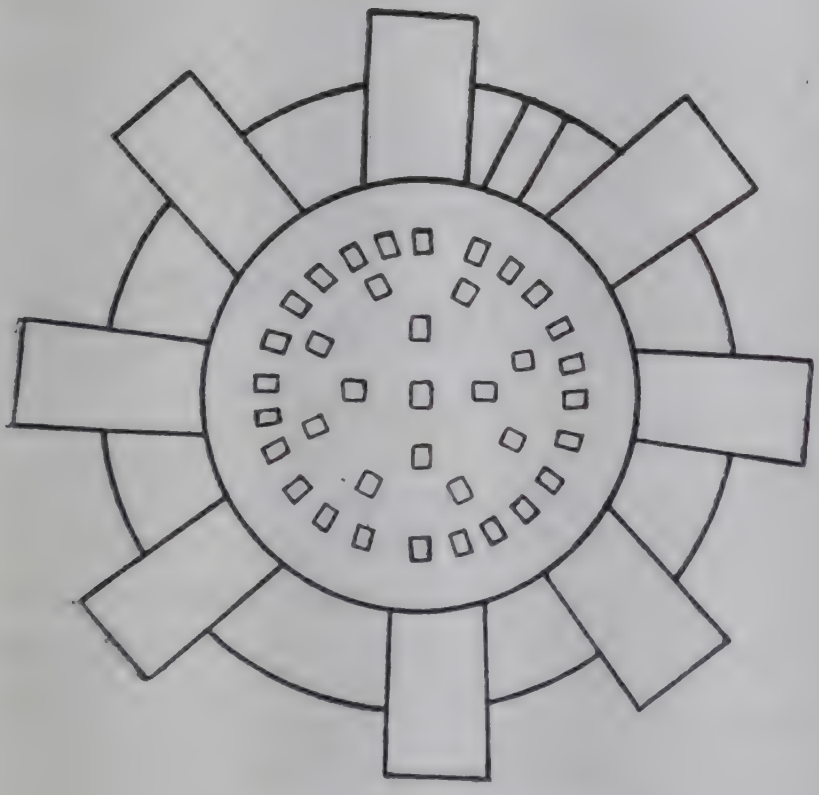


DOUBLE CHAMBERED PORCELAIN KILN.

By courtesy of Prof. H. N. Bose.

(940°C) was first used for biscuiting but it was found out that the article did not become sufficiently hard and the breakage was as high as 15 %. So the cone of 04A (1020°C) was used and the breakage at once went down to 5 %.

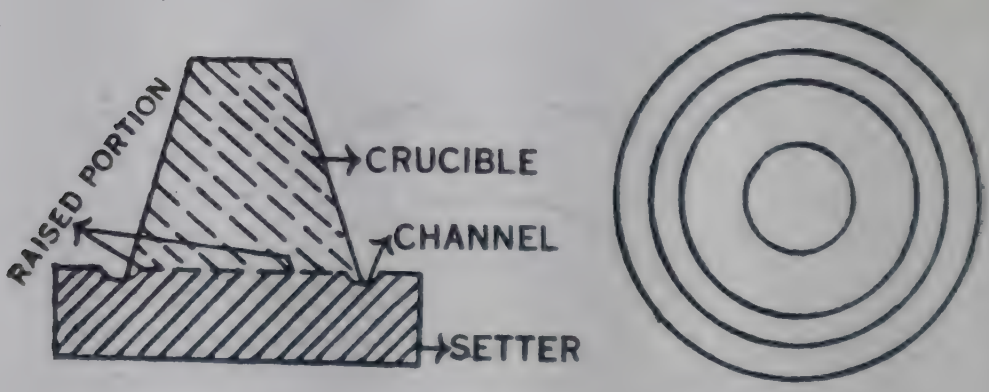
The Kiln used for biscuiting is a down-draught furnace, the figure of which is given below. If a muffle is used much better results will be obtained especially in glaze burning. Because the glaze contains tin oxide which is liable to get reduced in all other furnaces except muffle or electric. If a muffle cannot be used, an " Artificial Muffle " should be created by keeping one sagger inside the other.



SECTION OF THE KILN.

SETTING.

Setting is done in the following manner. Previously crucibles and evaporating dishes were fired just as the other articles are fired, i.e., with their bottoms down. Later on it was discovered that since these articles are very thin they get deformed or warped at high temperature (above 1040°C). Therefore a method was to be found out to prevent it. "Setters" of the same clay of which the chemical porcelain is made were prepared and the crucibles and evaporating basins were kept inverted over it. How the placing is done is illustrated in the following diagram.



SETTER.

The figure itself provides the explanation of adopting this method. Since both the setter and the ware are made of the same clay, the shrinkage of both will be the same and therefore if the crucible shrinks, say by 15 %, the setter will also naturally shrink by 15 %. Now since the setter fits into the crucible or basin just as the lid fits into the jar, the article does not get any chance

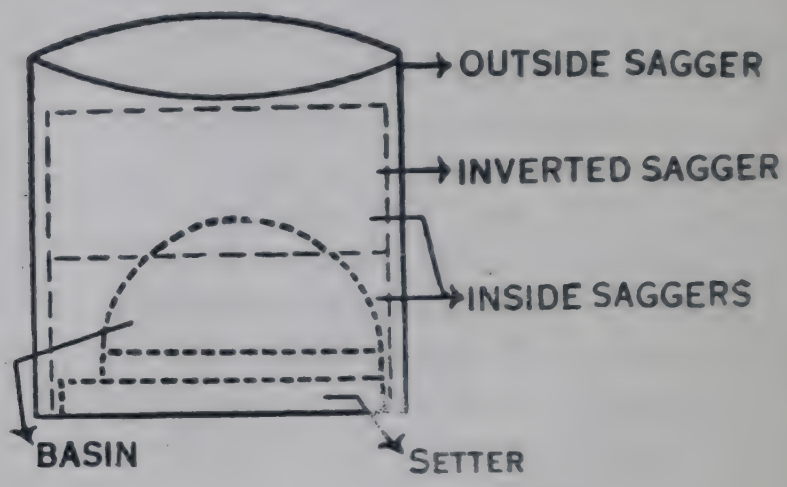
to be deformed or warped. Basins can also be placed in this manner.

The moulds of such setters are easy to prepare. A clay or wooden model of the setter is prepared according to dimensions and Plaster of Paris in liquid condition is poured over it. The plaster is allowed to set and dry. The mould is then ready for use. The slip or liquid clay is then poured in it and allowed to remain for a little space of time and then poured out. A thin film of clay will be sticking to the mould. Inferior quality of clay is then taken and is pressed into the hollow portion to fill up the gap. This process is necessary to give strength to the setter, otherwise it may shrink down at high temperature. The question may be asked why inferior quality of clay is used for filing the gaps. The answer is economy. If the setters are allowed to get solid, much clay will be unnecessarily wasted because these setters are useless after one firing. The shrinkage of the filling clay should correspond with that of original clay.

After this comes the important step of keeping them in " Saggers." Saggers are nothing but fireclay boxes which guard the wares from outside influences. Saggers should be of such dimensions as to facilitate the handling of the goods in and out of the sagger. Much space should not lie empty, otherwise the output of the goods from the furnace will be comparatively reduced.

The size of the saggers best suited for 4½ cm. crucibles and basins of 10 cm. diameter is 9" × 2½". This sagger is placed inside the sagger having

dimensions 11" × 6". This sort of arrangement is called " Artificial Muffle."



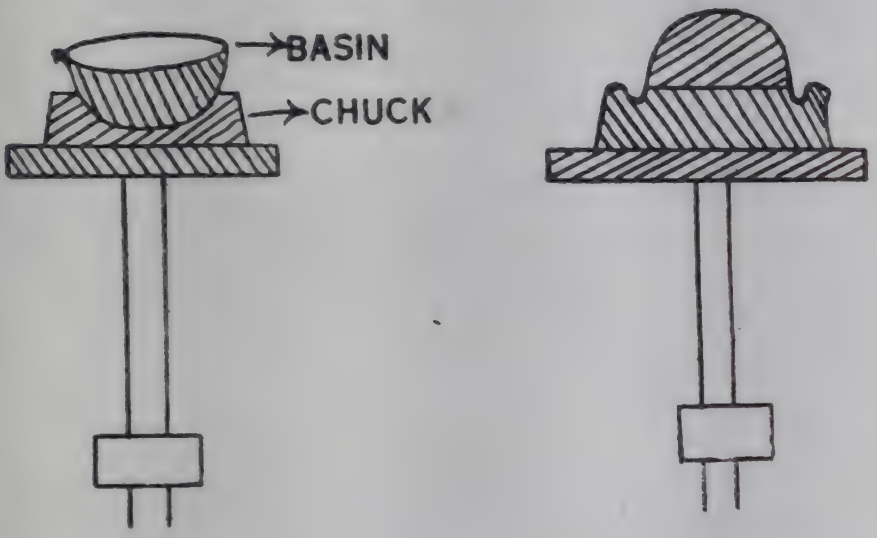
ARTIFICIAL MUFFLE.

This muffle bars admission to outside gases and thus protects the article from the evils of it. After the last sagger has been kept, the furnace door is closed and the furnace fired. Wood or coal or both can be used. Experiments were made over wood-firing and results were most satisfactory upto 1000°C. After that the temperature refused to rise but then coal was used and the temperature rose to 1300°C. The type of the wood that was used was of the mixed type.

TURNING.

The articles that come out from the furnace are rough and have got sharp corners. These are smoothed by means of sand paper. The articles require cleaning from both the sides, so a clay-chuck is prepared and a hollow portion curved

into it by a tool so as to hold a basin. The basin will tightly fit into the hole and will not fly off when in speed. The sand paper is then applied near the edge and slowly brought to the centre. Too much pressure should not be exerted, else broken article will be the result. The sand paper to be used is of '*O*' number of brand.



NORMAL POSITION.

INVERTED POSITION.

After the inside portion has been cleaned the basin is inverted and the outer portion is cleaned. The outstanding difficulty in this process is that the edges cannot be smoothened because of the projection of the beak. It has to be cleaned later by hand.

Crucibles can also be cleaned by the above mentioned method. The real trouble is caused by the crucible lid. In casting if the slip is allowed to remain for a few seconds more, the lid becomes thick and consequently entails much trouble in

cleaning. This lid does not fit properly into the crucible and is liable to fall down at the slightest jerk. Therefore a rim is to be carved out in such lids by sharp tools. This is troublesome process because the rim is liable to become of unequal thickness if the wheel does not move steadily. The speed should range from 250 to 300 revolutions per minute.

GLAZING.

Glazes are vitreous coatings on clay-articles in order to make them impermeable to water and also to give decorative aspect to them. The glazes suiting the above mentioned bodies are given below:—

0.11 K_2O 0.67 CaO 0.22 MgO	Al_2O_3	10 SiO_2
or		
0.3 K_2O 0.7 CaO	0.5 Al_2O_3	4 SiO_2
or		
0.85 CaO 0.09 Na_2O 0.06 K_2O	$0.5Al_2O_3$	4 SiO_2

These glazes possess the property of resisting alkaline or acid solutions and are so hard that when the ware is heated on clay-pipe triangle by a blast-burner the glaze should not stick to the pipe.

The biscuited bodies are then cleaned carefully by a piece of cloth to remove all the dirt. This step is necessary, otherwise the glaze may present a very rough and dirty appearance after glaze firing. Pin holes and peeling may also develop. Soap solution is then applied to the basin and crucible just near the edge to the width of $\frac{1}{8}''$. This prevents the glaze from sticking to that surface and the troublesome process of removing that much glaze is eliminated.

A sample piece is then dipped into the glaze and the thickness of the glaze checked by removing a little from the surface. After the glaze of proper dilution has been obtained, the basins and crucibles are dipped and kept in inverted fashion over a plank. They are kept thus because the glaze near the edge has to be removed. When the articles have dried, the soapy part is carefully deprived of all the glaze. Later on the articles are placed over the respective setters and are ready for glaze-firing. In this case one thing should be noted that the articles are placed over the respective setters. If a mistake is committed, deformed articles will be the result. So it is safe to number the article and setter by an organic colour or dye.

GLAZE FIRING.

After this comes the second-firing which is technically known as *glaze-firing*. The temperature used for glaze firing is near about 1400°C but the author himself has prepared a porcelain which vitrifies at about 1300°C and stands all the

tests. This temperature is maintained for one hour and a densely structured translucent quality, comparable to any foreign article is obtained.

It has been already stated that an " Artificial muffle" is essential if we are to get good results. " Artificial Muffle" is created by keeping one sagger inside the other. This serves a double purpose. Even if one sagger cracks since there is another sagger inside, the flue gases cannot enter and the article is safe. Question may be asked what is the influence of the smoke over the glaze ?

The answer is that dry, rough, pin-holed glaze may result. At high temperature the glaze absorbs the carbon and if this carbon does not get sufficient time to oxidise, the above mentioned results may appear. The second advantage is that even if the lines crumble down, the articles remain safe since the inner sagger is very rarely affected. These articles can be refired. They are not altogether a loss.

The temperature is raised slowly so that the articles get sufficient time for vitrification. When the required temperature has been reached, it is maintained for one hour to give sufficient time for glaze to melt. In the last stages of firing it is advisable to keep the atmosphere slightly reducing since it imparts a slightly bluish colour to the body so much appreciated in porcelain. But this only an expert can do. An inexperienced man must not try to effect that kind of thing otherwise smoked articles will be the result. It should be done very slowly. The upper block (cooling

arrangement) should not be opened before 8 hours after the firing has been stopped, otherwise many saggers will break. The damper should not be fully raised up at the same time. The oven door should be opened after 24 hours.

After the articles come out it is found out that they stick to the setters. They are released by striking the exposed part of the setter slowly. After this an emery stone is rubbed hard against the surface to smoothen it.

DEFECTS.

Defects in chemical porcelain are of two types: (1) in body, and (2) in glaze. In body the main defect is warping. This is prevented by using setters. Defects in glazes are of numerous types. For curing these defects any book on pottery should be referred.

PROPERTIES.

Laboratory porcelain should possess the following properties :—

(1) High resistance to heat so that it does not show any signs of fusion when heated to a temperature of Seger cone 30.

(2) High mechanical strength when heated so that it does not show any signs of bending or warping at the temperature at which it is to be used.

(3) It must not be damaged by sudden and rapid changes in temperature, when a red-hot piece is plunged into water, or is subjected to a sudden blast of air.

FOOD TECHNOLOGICAL RESEARCH INSTITUTE LIBRARY

(4) It must be impervious to gases, acids or alkalies and any other substance with which it may come in contact when in use.

(5) When a freshly fractured surface is treated with red ink the latter should be entirely removed by washing.

(6) The glaze must be sufficiently resisting to the material which the ware is to hold, otherwise the article will be useless. This may be tested by boiling caustic soda or H_2SO_4 and then determining the difference in weight.

(7) A thin transparent section when examined under the microscope should show a good development of sillimanite crystals.

FACTORY ESTIMATE.

A rough estimate of the factory is given below :—

1 (A) *Capital required for building and land.*

The land required is approximately one acre. The price of it is approximately Rs. 1500.

(B) *Buildings* :—

(1)	Room for Raw Materials	200	sq. ft.	$= 10 \times 20$
(2)	,, Engine or Motor	100	,, ,,	$= 10 \times 10$
(3)	Glazing room	400	,, ,,	$= 20 \times 20$
(4)	Furnace room	1500	,, ,,	$= 30 \times 50$
(5)	Sagger and Grinding Dept.	1200	,, ,,	$= 30 \times 40$
(6)	Godown and office etc.	900	,, ,,	$= 30 \times 30$

Total area 4400 sq. ft.

Building charges at the rate of Rs. 2/4 per square foot Rs. 9900

(C) *Furnaces* :—

Refractory Bricks of 8″ × 3½″	Rs. 5000
One Plaster Furnace	Rs. 500
One Trial Furnace	Rs. 500
	Rs. 6000

(D) *Machinery* :—

(1) Either an Oil Engine or Electric Motor of 10 H.P.	Rs. 6000
(2) Two grinding cylinders of 2′-6″ × 3	Rs. 2600
(3) Wooden Blunger	Rs. 500
(4) Filter Press 10 Chambers	Rs. 3000
(5) Diaphragm Pump 2½″ dia.	Rs. 2000
(6) Screw Press	Rs. 1200
(7) Pug Mill	Rs. 2500
	Rs. 11,800
(E) *Racks for keeping goods*	Rs. 1000
	Total Rs. 36,200

II. The above-mentioned furnace can accommodate about 200 Basins of 10 cm. size. The price of one basin is four rupees. If ten furnaces were fired a month about 2,000 basins will be produced. If 1/6 of them were spoilt still we will have 1,700 Basins. So the total income will be 6800 rupees every month. That is 81,000 rupees every year.

III. *Annual Expenses.*

(A) Raw Materials

Clay 1 ton every month at Rs. 60 a ton	Rs. 60

By clay is meant chemical porcelain clay.

(B) Labour charges

(1) Two men for fiywheel press	Rs. 30
(2) Two men for filter press	Rs. 30
(3) One man for sagger breaking	Rs. 30
(4) One man for glazing	Rs. 40
(5) Two men for firing	Rs. 50
(6) One man for sagger making	Rs. 40
(7) One man for miscellaneous purposes	Rs. 30
	Rs. 250
(C) 20 tons of coal for 10 furnaces on the basis of two tons of coal for each glaze furnace, at Rs. 23 a ton	Rs. 460
(D) Engine or Electricity expenses for 25 days	Rs. 125
Total	Rs. 895

Annual Expenses on this basis come roughly to Rs. 10,000.

IV. *Other Expenses.*

Interest will be given at the rate of 9 % on Rs. 36,200 and Rs. 10,000 which are respectively fixed and moving capitals.

(A) Interest at the rate of 9 %	Rs. 4150
(B) Commission at the rate of 20%	Rs. 4000
(C) Office Expenses	Rs. 1000
(D) Manager's salary	Rs. 2000
(E) Repairs	
Furnace	Rs. 1000
Machinery	Rs. 500
Buildings	Rs. 500
Miscellaneous	Rs. 500
	Rs. 2500
Total	Rs. 13,650

Total expenses may thus be summarised as follows :—

Annual Production Expenses	Rs. 10,000
Other Expenses	Rs. 13,650
	Rs. 23,650

V. *Profits.*

Total Capital	Rs. 46,200	
„ Income	Rs. 81,000	
„ Expenses		Rs. 23,650
„ Profit		Rs. 57,350

Total profit about 125 %.

N. B.—Certain things have been assumed in the above estimate. For example, the wages have been charged at a slightly higher rate. All the machineries are not essential. Some of them can be dispensed with. The price of the land is imaginary.

PROSPECTS.

India presents a vast field for the production and marketing of such goods in the form of Scientific laboratories. Every laboratory whether it is physical, chemical or metallurgical needs crucibles and basins. No patriotic man will ever think of purchasing foreign goods except only when compelled by necessity. That kind of dependence on foreign articles will be eliminated as soon as the required goods will be produced in India.

The possibility of the production of these goods will have to be viewed from three angles. The first is the raw material. China clay is available in India in every Province in more or less proportion. Bihar abounds in it. The second is the Government backing. This is very important. The third is the " a-going " spirit of the industrial magnates and the wealthy people who take pleasure in depositing their money in Banks.

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III.

MANUFACTURE OF SURGICAL INSTRUMENTS IN INDIA

By YAKOOB KHAN

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INTRODUCTORY.

THE great effort made by India to solve one of the most important problems which arose within a year or less of outbreak of hostilities has proved very creditable to the medical authorities. That was to produce within the country as many as possible of the surgical instruments formerly imported. The surgical instruments industry in India is centred mainly at one place at Sialkot in the province of Punjab, though there are firms manufacturing these instruments in Bombay and Calcutta also. This is so because surgical instrument manufacture is one of those industries where mass production methods have not yet been generally applied, and the instruments have to be made by highly skilled hand labour which is abundantly available at Sialkot and its neighbourhood. Here the industry has flourished for over fifty years and has become almost a home industry. The instruments turned out are consequently of a very superior quality. Due to the huge require-

ments of the Government and the military, the industry has been developed to a very great extent and the range of instruments manufactured is really vast and is continually increasing.

MATERIALS.

The most important raw material required for the manufacture of surgical instruments is steel, of carbon content varying from 0.4 % to 1.2%. Mostly plain carbon steel is used, but sometimes an alloy steel like stainless steel is also required. The steel is mostly required in thin sections, e.g., 1″ × ¼″ or 1″ × ½″, and hence is generally rolled. Brass is also used for handles, etc. of some instruments.

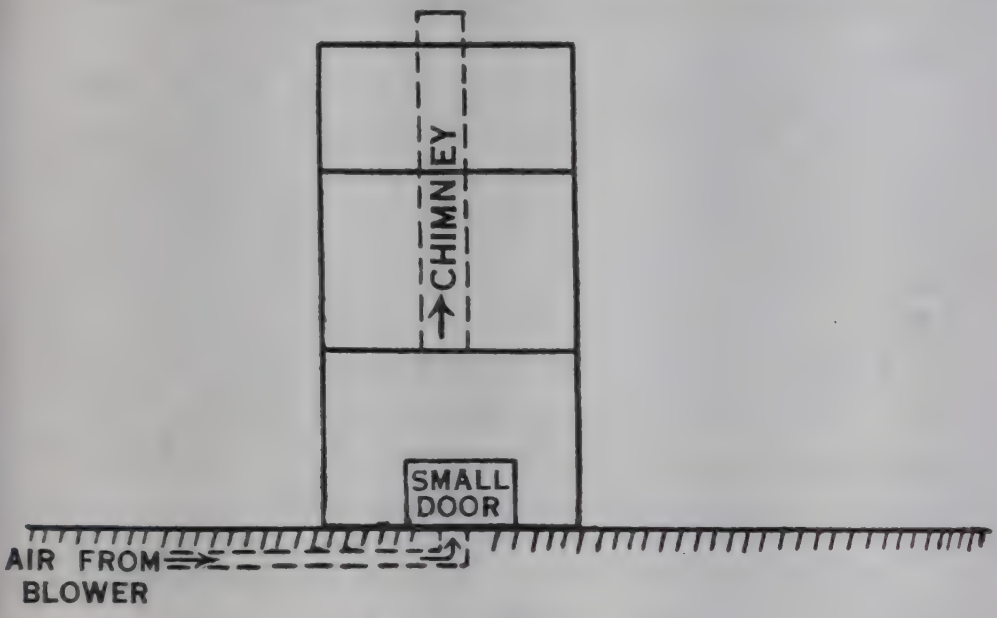
The steel used for surgical instruments must be of the very best quality, and one where the percentage of carbon specified can be relied upon, for these instruments require the maximum possible strength with a minimum of weight, and any flaw or discrepancy in the steel would be ruinous to their quality. Hence it would be poor economy to invest in cheaper steels of doubtful quality for surgical instruments.

OUTLINE OF METHOD OF MANUFACTURE.

A very brief outline of the method of manufacture is as follows :—

Steel pieces of suitable length and section are heated in a blacksmith's furnace (page 59), about 3 ft. high and 1 ft. broad at the base and when properly heated are hammered to the right shape on an *anvil*. They are then filed to give a

uniform and smooth section of correct dimensions, and also to give cutting edges, serrations, etc., where required. The instruments are



Forging Furnace.

then hardened and tempered. Finally, they go through the finishing process of grinding, polishing and plating. Let us consider different steps in the manufacture in detail.

FORGING.

The traditional method of forging surgical instruments is a purely manual process, the forger requiring for his work a hearth of fine coke or charcoal, kept burning vigorously by air blast from a hand or motor operated blower, an anvil or stithy, and hammers, tongs and other tools; these he operates throughout by hand. In the forging of light articles, such as knives, scissors,

forceps and the like, the forger works in solitary fashion ; but for making the larger instruments, two men are usually required, the maker being assisted by a striker who manipulates a heavy hammer.

As an illustration the forging of a knife (scalpel) may be taken. A suitable length from a flat steel bar is raised to a glowing red heat in the hearth. The forger then draws out and moulds the glowing metal into the formation of a rough blade. The piece is heated again and now the part which forms the handle is forged. A third heat allows the whole to be well smithed over and the shape carefully corrected by the help of suitable length and sectional gauges.

The following points should be carefully observed for forging work:—

1. The heating should be gradual and uniform throughout.

2. The air blast in a smith's hearth should not impinge directly on the steel, as this is liable to produce hard and soft places and risk of cracks in hardening.

3. Carbon steel should not be forged at a lower temperature than about 560°C (brown red), as this is liable to produce strains which may result in cracks in the subsequent hardening.

The greatest change that is taking place in the forging practice is the introduction of die-forging in place of hand forging. With properly designed dies, a much more uniform product can be turned out and at a much faster rate.

FILING AND FITTING.

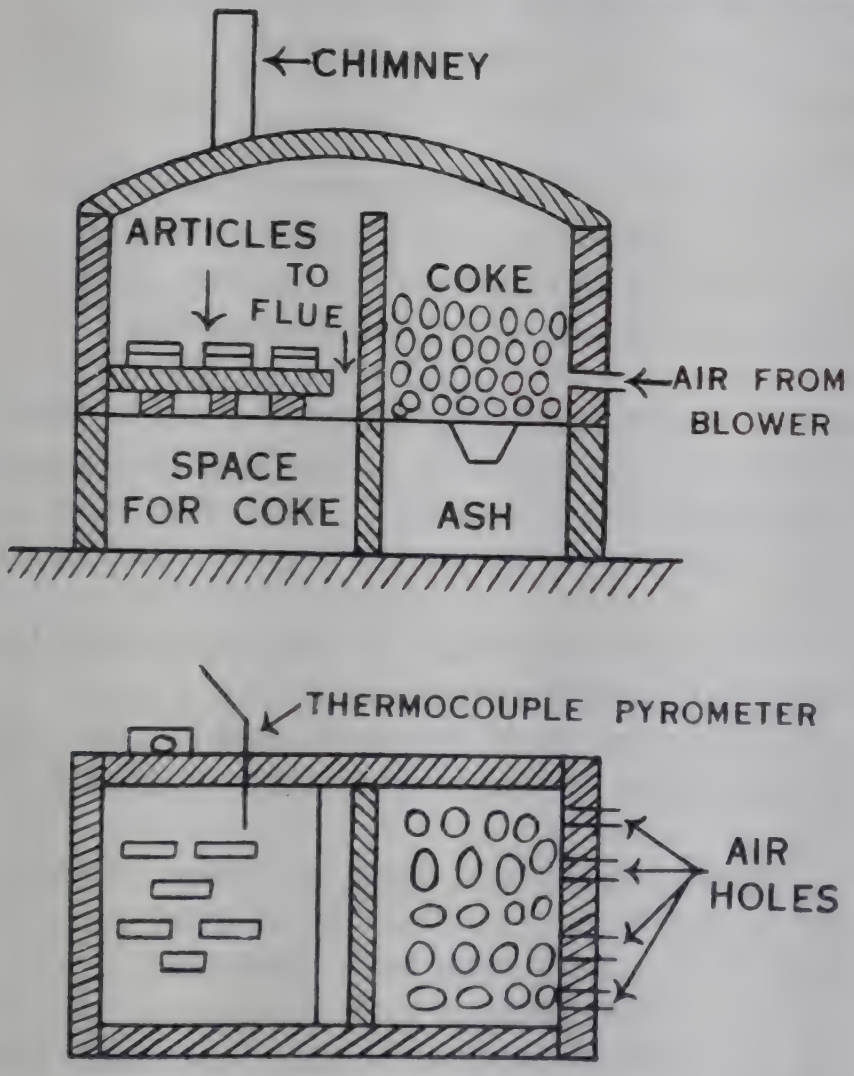
The second operation on the forged instruments is that of filing them to the specified dimensions with the help of gauges. The forgings may be annealed if found too hard for filing. Two kinds of gauges are necessary for any instrument, one called the filing gauge, which is kept 15 to 20 thousandth of an inch oversize to allow for loss of material due to scaling in heat treatment and also due to grinding and polishing. The instruments are filed so as to just fit these gauges. An illustration of such a guage for one type of Scissors is shown overleaf. The other set of gauges is made to the exact dimensions and is meant for checking the finished product.

After correctly filing, the instruments go to an expert hand for correct fitting. The joints must neither be too light nor too loose; the cutting edges must be given the proper angle, and such other fine points which go to make a good surgical instrument. Serrations at the ends in instruments like the dissecting forceps are machined at this stage. A milling cutter with serrations of the required pitch and depth is made and the serrations are milled on the instrument which is held in a suitable fixture on the milling machine. A lather can also be utilized for machining serrations, provided a suitable fixture is made. In the absence of any machine tool, it is surprising how accurately a trained hand can cut serrations with a small file.

Example of a Gauge for Surgical Instruments.

HEAT TREATMENT.

After the instruments are filed and fitted, the next and the most important operation in the whole process is that of heat treatment. The operation involves, first hardening by heating to the correct temperature and quenching in oil or water, followed by tempering at temperatures varying between 250° C and 380° C or higher, according



Heat Treatment Furnace.

to the instrument and the carbon content of the steel. For hardening a furnace of good design is necessary so that the temperature inside can be accurately adjusted and be uniform. Most modern furnaces are gas or oil fired or electrically heated, though coal would be cheaper on a consideration of the cost of B. T. U. absorbed in the work. A muffle furnace of the type shown, where coke is burned in one chamber and the articles are heated by hot gases and flame in the adjoining chamber, would be found quite good for surgical instruments.

The process of heat treatment is as follows :—

The instruments to be heat treated are first normalised in the furnace by heating them to a little above the hardening temperature and taking them outside and cooling them in the air. The correct hardening temperature for steels mostly used in the manufacture of surgical instruments varies from 750°C to 810°C, depending upon the carbon content of the steel. They are then heated again tc the proper hardening temperature, held at that temperature for the requisite time, and taken out and quenched in oil or water. The instruments are now in a hard and brittle condition and must be tempered to make them serviceable.

There are several ways in which tempering can be done, e.g., by heating in sand on a hot plate, or in a tempering bath consisting of a mixture of molten sodium and potassium nitrates. The last named method is the best and gives uniform results as are required for surgical ins-

truments. As mentioned before, surgical instruments are tempered at temperatures varying from 250°C to 380°C. In a bath of molten sodium and potassium nitrates tempering is usually done by the colour method, the colour ranging from dark straw or brown yellow for bone cutting instruments like chisels, to purple for general instruments like forceps, and blue for instruments requiring a spring action. Bigger instruments, which are not required to be very hard, but which should not have any brittleness left in them, are tempered at about 380°—400°C which is beyond the range of tempering colours.

GRINDING AND POLISHING.

The articles after heat treatment go for grinding and polishing prior to being electroplated. Rust and scale are first removed by pickling for 10-15 minutes in a 10 % solution of sulphuric acid.

The instruments are then ground progressively on grinding wheel, emery wheel, and leather bobs coated with fine emery, and finally given a polish with a polishing mop. A polishing lathe of good, sturdy construction is required, which should be capable of running at a high speed without shake or vibration. For polishing mops, a surface speed of from 4000 to 9000 ft. per minute is required. In polishing, high speed means better results, increased length of life to the mop, and less consumption of polishing materials.

CLEANING THE ARTICLES.

The basis of all successful electroplating is perfect cleaning. Faulty cleaning is the cause of many troubles in the plating shop, most cases of stripping being directly attributed to bad preparation of the work. By the word " clean " is meant —not merely clean to the eye, but chemically clean. It is necessary to free the surface of the article from every trace of foreign matter, oil or grease.

The latest development in the cleaning process is what is known as the electrolytic degreasing process, which permits the employment of an electric current for the cleaning process. A tank made out of sheet steel is connected to the positive pole of a dynamo, whilst the instruments which are suspended in it are connected to the negative pole. The dynamo mentioned above is a 6 Volt dynamo which is necessary in every plating shop. The solution inside the tank can either be an acid or an alkali. For surgical instruments generally, a solution of 1 lb. caustic soda and 1 lb. washing soda in a gallon of water is found to be satisfactory.

A pressure of 2-3 volts, giving a current density of about 20 amperes per square ft. will result in the free evolution of gas from the suspended articles which form the cathode. The grease will not only chemically combine with the soapy solution, but it will also be swept away by the released gas, leaving the surface clean and ready for swilling. The articles are kept in the tank for a few minutes only and are then taken

out and thoroughly swilled in water. They can then be transferred straight away to the plating tank.

ELECTRO-PLATING.

The next and final stage in the process is the plating of instruments. We will only consider here nickel plating, as this is the most common plating for surgical instruments, though chromium plating is also employed for some type of instruments. Prior to nickel plating, the instruments are copper plated. This is because nickel deposits more easily and firmly on copper than on any other metal. The deposits of copper and nickel must each be about half a thousandth part of an inch thick. It would be long and out of place here to go into details of the correct plating baths and the methods of making them, the proper current densities, etc. These informations can be had from any good book on the subject.

The articles after plating have a dull appearance. To give them the characteristic shine of plated articles, they have to be buffed. For this a linen or calico mop is set on a polishing machine spindle. A bar of suitable polishing material is pressed against the rotating mop so as to form a coating of this polishing material on the periphery of the mop. The floated article is then polished by pressing against the rotating mop. The surgical instrument is now ready for use.

LAYOUT OF THE FACTORY.

A factory for manufacturing surgical instruments should have the following separate sections:—

1. *Forging section.*
2. *Filing section.*
3. *Machine shop.*—Though machine tools are not an absolute necessity for surgical instrument manufacture, yet a medium-sized lathe, a small drilling machine, and a hand press are very useful. A small horizontal milling machine would also prove very useful.
4. *Heat Treatment section*—Two furnaces, one for hardening and the other for tempering, constructed of refractory firebricks, constitute the main equipment of this section. A motor operated blower is also required.
5. *Grinding and Polishing section*—Here the instruments are ground and polished prior to plating on polishing lathes. This section should be a little separate from the rest of the factory to prevent the dust and the dirt of grinding from fouling the air of the rest of the factory.
6. *Electro-plating section*—This section should be well protected from outside dust and should be well ventilated and maintained scrupulously clean.

The cost of starting a factory of the type mentioned above depends on many factors, the most important of which is its size. Taking an estimated outturn of 3000 (three thousand) instruments per month, a single storied building, occupying an area of about ¼ acre should be sufficient. The cost of equipment, including heat treatment furnaces but excluding the machines, should not exceed fifteen thousand rupees at the present time. The building which is not required to be very

strong may cost another ten thousand rupees. The cost of the machines depends on their number and quality, and hence cannot be estimated with any accuracy.

CONCLUSION.

The surgical instrument industry in India is by no means a new industry. But it has lagged behind other equally old industries and has not made much progress, mainly because scientific methods of manufacture were not applied to it until now. The local manufacturers were content to go on in their small way, with the result that an industry with such great possibilities, particularly in the Punjab has remained more or less a home industry. This war has been a boon to the surgical instrument industry in India, mainly because of the technical assistance given to it by the Government to increase production of the much required instruments. The greatest improvement has been in the heat treatment of these instruments, for it was here that Indian made instruments lagged behind the foreign ones. Excellently made instruments were rendered useless by faulty heat treatment. With the much improved methods of production and heat treatment, and the much increased output, the surgical instrument industry in India is now on a very sound footing, and should prove to be a very formidable competitor, after the war, for foreign instruments, at least in the Indian market.

IV.

SPECTACLE FRAME MANUFACTURE.

By MASOOD HUSAIN,

Prop. Novelty Products Co., Pipalmandi Road, Agra.

GOLD, silver, rolled gold, nickel-plated and gold-plated spectable frames of foreign make have now over-flooded the Indian market. The manufacture of these necessaries can be now taken up by our countrymen to reduce our dependence on foreign products. The process is not at all complicated, nor do we need the help of any foreign machinery in their manufacture except the electric motor. The prospect of such an industry can not be overestimated in view of the ever-growing demand for frames in India.

PROSPECTS.

If the manufacture is undertaken it will advantageously augment the list of our cottage industries like watches in Switzerland, utensils at Moradabad and shoes at Agra. There will also be no need to import these goods any further as India will then be in a position to produce thousands of good workmen and trained labourers and there will be hundreds of workshops producing spectacles of all shades of refinement in taste among the consumers.

Capital required to start this work is about 5 to 6 thousand rupees. It is expected that in about four months it will be amply repaid during this period of high demand.

MACHINERY REQUIREMENTS.

The following machines are required to do the work from wire to the finished article :—

1. One lathe hollow spindle about four feet.
2. One lathe hollow spindle about 2 to 3 feet.
3. One small fly hand press to cut side joints.
4. One small fly hand press to make nose bars (bridge).
5. One small fly hand press to rivet side joints.
6. One small fly press to press sides.
7. One rolling machine to make grooved wire (four spare rollers to make different shapes of wires).
8. One electric motor ½ B.H.P. or ¼ B.H.P. for polishing.
9. One electric fan (ceiling) and this will be converted as small motor with small blades for furnace blast fan. 'Crompton' or 'India' ceiling fan will do. It should be ball bearing type as it is to be worked several hours day and night.
10. One iron tank seamless, welded and air-tight.
11. Two small hand drills.

PROCESS OF MANUFACTURE.

First round wire is drawn by ordinary process which is universally known. It can be done by

hand, foot or power. From wire thus drawn every piece is made. The process of the manufacture can be summed up as follows :—

NOSE BARS OR BRIDGE.

This is done on fly hand press by simple dies. The die will press and make the bar into the shape desired. No hand work is necessary. Even a boy can easily do the needful.

MAKING LENS HOLDERS.

The round wire is placed on the rolling or grooving machine which is provided with grooved rollers. This will make the groove in one operation and roll several thousands of yards in a day.

The grooved wire is then wrapped on wood roller or iron roller of the size and shape of the lens. For instance, if you want 00 size or 40 mm size, then these rollers are made of this size and shape with a slight margin for cutting. This grooved wire is wrapped on these rollers either on the rolling machine or lathe, and when the whole roller is wrapped from one end to the other end (both ends being locked into holes provided into rollers), a cutter circles this either on the lathe or in the rolling machine and then cuts this wrapped wire from one end to the other. In this way bangle-shape cut pieces come out of one size and shape. This is an easy, simple and inexpensive method of making Lens Holders.

SIDE JOINTS.

The joints can be cut on fly press by dies from sheets or on the rolling machine. If cut on the

rolling machine the following procedure may be adopted. The grooves are made and sunk successively on the rollers and the round wire is pressed through this which becomes flat with raised joints like embossing and then these small joints are cut on press.

When they have been cut on the press they are placed on the drilling machine which makes the holes. After the holes are made these are placed on the other drill which makes thread.

SIDES.

The side is composed of two parts : the solid part and the flex part. The flex part is made on the cabling machine. This is a very simple machine and it is the same as ordinary "Kalabatto" making machine. It is fully automatic and makes several yards in a day.

The hard wire is soldered to the flex wire and then it is rolled into grooved rollers on the rolling machine and then pressed on the press to give hardness to sides. The end piece is again pressed and cut by dies which makes the hole and makes left and right. It requires a little experience and in about one hour a boy is trained and the system goes on.

SOLDERING.

This is a complicated method. It requires a little skill and any solderer can be trained in a short time. Any goldsmith or silversmith can do it easily. Ordinary solder is used. For gold, gold solder is used, for silver and other plated goods

silver solder is used. It requires about 100 or more special pincers made for this work and these pincers hold the bridge, the lens holders, the side joints and it is adjustable by screw guides. It keeps all these parts in position and together. The boys start assembling these parts to these pincers and heap them. The solderer puts the solder and starts soldering them by mechanical blow pipes like gas welding and the flame is sharp and acute. Mustard oil lamps are used and kerosene oil is not required. The electric fan is started and the air is stored into the tank. From the tank there is another pipe line. From this pipe line take as many connections as you please by rubber tubes. At the end of the tube the blow pipe is fitted which has the lock for the air. Turn on the lock when air is required. Air comes through the blow pipe and falls on the flame of the mustard lamp and this makes a gas flame. This is a simple way like mouth blow pipes known to every silversmith but the only difference is that it is worked by motor and the silversmith does it by mouth.

FINISHING.

After soldering these are pickled in acids and polished on polishing machines and plated in the usual way.

RIVETTING.

The side joints are rivetted with pins on the press. It is very simple. The die required for this operation is made of Air steel.

TINY SCREWS.

These are the only things that give rise to difficulty. These can be made on the lathe by making a slight change in the lathe for mass automatic production.

Persons of low capital can also take up this industry. They need not keep so many machines but keep a few and make dies. They can make one part one day, the other parts next day and so on and then start assembling and so on.

V.

MANUFACTURE OF PENCILS—I

By P. S. KAPOOR, B.Sc.

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THERE is plenty of scope for manufacturing pencils in India. The demand is very high now and is expected to run high even in post-war years.

RAW MATERIALS.

All the raw materials for pencil manufacture can be had in large proportion in India. The following are the important raw materials required for pencil making :—

1. Graphite (amorphous).
2. Clay (Soap Stone, Ball clay, China clay).
3. Soft wood.

Graphite can be had from Mysore, Ceylon, Dandi (Punjab), Kashmir (Near Jammu), Faziabad (Dehli). The best purified graphite is, of course, that of Ceylon. But, usually that is not available.

Soap-stone is an article much used in commerce. The soap makers employ it on a pretty large scale. It is not very costly. It is good as far as its lustrous and weighty qualities are concerned.

Ball-clay is found in abundance. It may be termed in vernacular as Gachni Mitti and can be had at as. -/1/6 a seer.

China Clay should be 100 % pure. The least amount of impurities cause the baked lead to smother and spread on the paper.

Soft wood is a very important consideration in pencil making. From my practical experience I have found *Juniperus macropoda* and *Juniperus recurva* to give the best result.* Soft wood from Quetta (Baluchistan) and from Kashmir also answer very well.

PURIFICATION OF GRAPHITE.

Graphite can be purified by the following two methods :—

GRAVITY PROCESS.

Place graphite in a drum filled with water and let it stand for a day thoroughly stirring the contents. Remove the upper layers which contain nothing but siliceous matter. Transfer the remaining graphite to the second drum by passing it through a rough cloth. Fill this drum with water and repeat the process till the upper layers are clear.

It may be noted here that this graphite will only be 40-50 % pure. Drums may be made of wood or of iron or cement of quadrangular shape.

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* Cupressus torulosa and Pinus excelsa are being used in pencil factories in India. Cedrus deodara, Podocarpus neriifolia, Pinus longifolio, Wrightia tomemtosa, cedrela toona, kydia calycina, and Mitragyna parvifolia can also be used but they are somewhat too tough.—Ed. *Industry.*

This takes at least 5 days but does not give good results.

FLOTATION PROCESS.

This method is very suitable and gives very good results.

The finely crushed ores (in this case graphite powder) are vigorously agitated with a little *pine-oil.* The graphite powder gets preferentially wetted by the oil and the gangue by the water. Bubbles of froth rise to the top, each bubble being covered by a layer of ore particles. The froth is skimmed off, and the concentrate thus obtained is subjected to the separation of oil process. Oil can be separated by the addition of alkali or some mineral acid. The froth is then heated in an iron vat and the vapours of water are thus formed and removed. The illustration on the next page explains the process.

The above process gives a very good result and if petrol* is added instead of oil, we get a very good result and a facilitation in the removal of oils.

PURIFICATION OF CLAY.

Clay may be purified by any one of the two methods given below:—

1. *Drum Method.* Transfer the contents to another drum and go on repeating as explained under gravity process for purifying graphite.

2. A modified form of the above method is described below.

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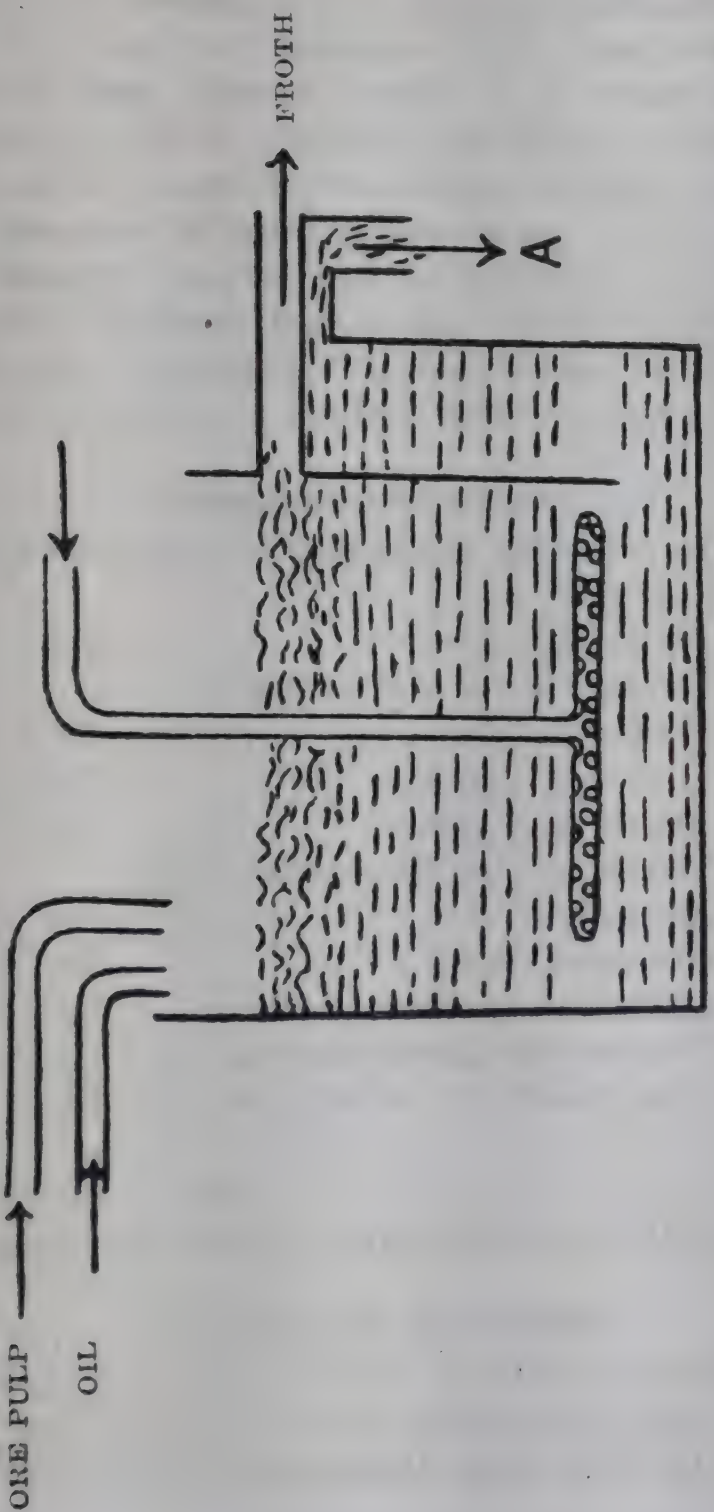
* Petrol may be used in the proportion of 35 lbs. of the ore to 1 gallon of petrol.—Ed. *Industry.*



A Indicates Gangue

Pass the clay and water as shown in the figure on the next page through the first vat and when there is a slurry formed open the tap T_1, and transfer the contents to Vat II using a coarse cloth or a sieve of 100 mesh. Repeat the process till a pure layer of water is obtained.

Soap-stone can be had as pure crystals and can be powdered and passed through cloth. It should be noted that this soap-stone should be shiny-white in colour and not as yellow streaks.

MACHINERY REQUIRED.

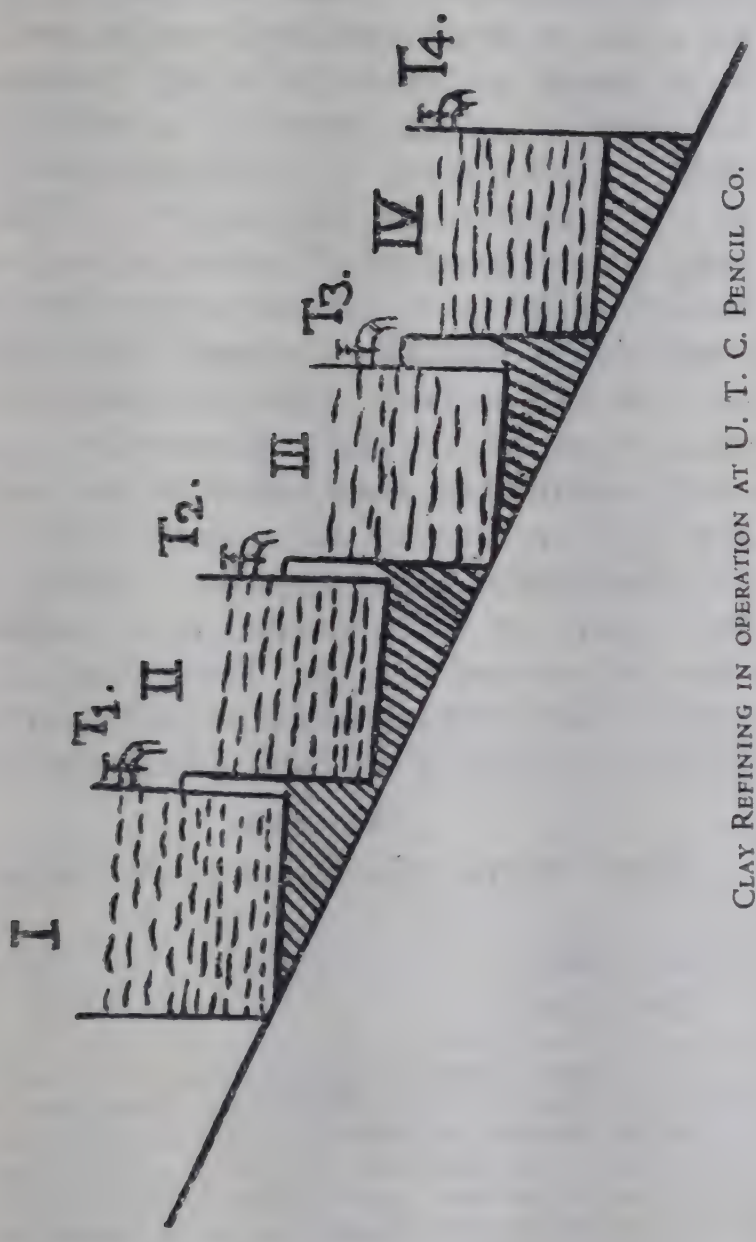
The following machinery are required for the pencil factory:—

1.	Crushing roller	Rs. 600/-
2.	Drum-mill for wet grinding	——
3.	Hydraulic press or screw press	Rs. 1,500/-
4.	Grooving machine	Rs. 1,500/-
5.	Shafts and pulleys	Rs. 900/-
6.	Wood-working machinery (tool-grinder, etc.)	Rs. 400/-
7.	Stamping press	Rs. 100/-
8.	Colouring machine	Rs. 800/-
9.	Presses for glued material (4)	Rs. 200/-
10.	Iron hearth or burning stove	Rs. 40/-
	Total	Rs. 6040/-

All the above machinery can be had locally.

PROCESS OF MANUFACTURE.

Pure graphite is mixed with ball clay and soap-stone and ground to an extremely fine powder, and then very thoroughly mixed with the



Clay Refining in operation at U. T. C. Pencil Co.

necessary quantity of water so as to form a dough of considerable thickness. This dough is now pushed through holes of suitable size so as to form round thin sticks. These are then kept covered for a day to avoid rapid evaporation and then put in the sun or special ovens, to dry them up. These are then cut of the length of a pencil each and then sent for baking. It is continued for 2-3 hours at a temperature of 1000-1200°C. This heated mass is now cooled out of contact with air and then the sticks are taken out and dipped in a wide vat containing a mixture of stearic acid and paraffin wax for half an hour. The sticks are then taken out and put in saw dust. Meanwhile wood is cut and grooved, then glued and sticks are put in them and they are pressed for a day or two till they are thoroughly joined together. These slits are now taken out and modelled in a moulding machine into round pencils. These are put one by one in wood working machine and sand papered. These round pencils are then coloured as desired.*

RECIPES.

Some of the recipes are given below :—

I.

Graphite	50 %
Ball clay	20 %

* The pencils may be then stamped with maker's name and quality such as H.B., H.H.H., etc. For plain impressed letters the pencils are pushed through between two circular spring dies which form the inscription as they pass through. When the letters are to be gilded, a little size is applied to the side of the pencil and a strip of gold or silver leaf is placed on. The stamp works in vertical guides and is heated by gas. The surplus leaf after impression is rubbed off and the pencils cleaned with a cloth.—Ed. *Industry*.

Soap stone	20 %
Borax	5 %
Lamp-black	2 %

Instead of lamp-black use carbon-black.

II.

Graphite	50 %
China clay	40 %
Borax	10 %

III.

Graphite	40 parts
Plastic clay	60 „
Gum Arabic	4 „

IV.

Graphite	25 %
Soap stone	25 %
Ball clay	44 %
Borax	4 %
Carbon black	2 %

This formula gives exceedingly good result.

A sample was prepared without borax and was found that the hardness of the lead can not be had as before and it is found that borax fills up any spot that may be left due to its swelling up property. It should be mechanically mixed in the powder form and then the paste should be made.

V.

(FOR 4 H PENCILS).

Graphite	27 parts
Antimony	9 „
Fuller's earth (Ball clay)	9 „
Sodium silicate	2 „
Borax	1 „

This formula is a great success. Great care has to be taken in the addition of silicate. When heated to a temperature of 1000°C it becomes nothing but glass. It should be soluble in water and dissolved in water before use.

VI.

Graphite	20	parts
Ball clay	40	,,
China clay	40	,,
Soap Stone	15	,,
Borax	4	,,
Carbon Black	1	,,

VII.

Graphite	12	parts
Ball Clay	22	,,
Soap stone	12	,,
Borax	2	,,
Sodium Silicate	2	,,
Gum Tragacanth	1/24	part

Keep the moisture for a day and put it in the grinding machine.

VIII.

Graphite	12	parts
Ball clay	22	,,
Borax	4	,,
Plaster of Paris	2	,,

This gives a very hard pencil.

COPYING PENCILS.

I.

Methyl Violet	4	parts
Graphite	3	,,
Gum Arabic	⅛	part

II.

Aniline dye	4 parts
Graphite	2 „
China clay	1 part
Gum Tragacanth	a pinch.
Sodium silicate	⅛ part

Dissolve the dye in water by heating. Mix clay and graphite together in a separate vessel and add water soluble blue colour 1 part. Transfer this to the above mixture and mix with suitable quantity of water. Add a few drops of strong sulphuric acid and keep it for a day. To this mass add silicate and gum tragacanth and wait for a day. Then put mixture in the press and get the thread. Keep the string under pressure or in a closed air-tight vessel and dry it in sun. Cut it in the form of a pencil and throw it in linseed oil hot for 15 minutes. The material is ready and put in the wood.

III.

PATENT FORMULA.

Aniline Dye	1 part
Graphite	2 parts
Gum Arabic	½ part

IV.

Methyl Violet	6 parts
Graphite	3 „
Ball clay	1 part
China clay	1 „
Sodium Silicate	1 „

COLOURING.*

For natural colour dissolve shellac in borax solution and apply it to the pencil and varnish it.

Take any varnish and dip the pencil in it and keep for a day. We get a very good natural colour. At least two coatings should be given.

LOCATION OF FACTORY.

The essential points for laying out a pencil factory are Raw material, Labour, Fuel, Power, Water supply and Markets. Of the above the markets play an important part. The vicinity of market will keep down the price of the products. It must be noted that although raw materials play an important part, this is not the only potent factor to be taken into account. Skilled labour is also essential. It is available near the towns. Power is also necessary for this industry. Hence a factory should be installed at a place where cheap power, skilled labour and markets are available.

ESTIMATE OF EXPENDITURE.

It is hard to give a factory estimate in this fluctuating market. On a rough estimate the

* Coloured pencil leads may be made thus: Take ammonium hydroxide 2 parts, shellac 3 parts, Venice turpentine 1 part, Prussian blue or other pigment 6 parts. China clay or chalk 4 parts. Grind the pigment to a fine paste with water. Dissolve separately the shellac in ammonia. Render Venice turpentine fluid by short heating. Next work the clay to a smooth slurry with water and press through muslin and then dry and powder. Now mix everything together in a mill until the consistency is that of a thick dough. This is then fed into a pressing machine with openings of the size required. The extended leads are placed in a drying oven for drying.—Ed. *Industry.*

initial expenses for complete installation will be Rs. 10,000/- at least. Moreover about Rs. 2000/- is to be spent on experiments, etc.

PENCIL MANUFACTURE—II.

By S. B. VAIDYA, L.M.E.

23, BHAI JIVANJI LANE, BOMBAY 2.

PENCILS can be manufactured in India. While in foreign countries, there are hundreds of factories for the manufacture of all sorts of pencils, in India the number of factories equipped to manufacture pencils is very limited. They are manufactured only in Calcutta and Madras. In the Punjab and Bombay there are no pencil factories now. Yet it must be admitted that the possibilities of manufacturing pencils in these and other provinces must be quite enormous.

Present is good time to manufacture pencils. Raw products for pencils are available in India on a very large scale. On account of abnormal conditions now prevailing inspite of the termination of the war, machineries are not available now. So we should make use of hand-power as much as possible. Training is not required for starting a small factory as common sense will be a guide to the attainment of perfection.

MACHINERY.

From the following list one can get an idea of what amount of capital is required to start a pencil factory to manufacture about 100 gross pencils per day. The prices are pre-war prices.

1 Drum Mill for wet grinding for 100 kg. mixture with electric drive	Rs. 1200
1 Crushing roller for graphite and clay with transmission drive	Rs. 1300
1 Vertical screw press for leads with transmission drive	Rs. 2100
1 Burning stove	Rs. 700
10 Graphite burning boxes	Rs. 200
1 Circular saw with motor	Rs. 1400
1 Slit saw	Rs. 700
1 Grooving and shaping machine	Rs. 1300
1 Tools grinding machine	Rs. 400
10 Glue champs	Rs. 400
1 Grinding drum	Rs. 700
1 Sand-papering machine	Rs. 1200
1 Sand-papering machine for hexagon pencils	Rs. 2500
1 Polishing machine	Rs. 2400
1 Varnishing machine	Rs. 1500
1 End Trimming drum	Rs. 600
1 Hand stamping press	Rs. 400
1 Dipping apparatus	Rs. 200

With buildings etc. the capital required will come to Rs. 40,000.

RAW MATERIALS.

To manufacture pencil on a small scale. instead of taking crude graphite and purifying it

one should take pure graphite which is available in Bombay in large quantity. Instead of taking big logs of wood and cutting them in planks of required thickness one should buy ready made planks. Wood should be soft and of straight veins. Cedar wood is used in foreign countries. Such wood can be got from Indian forests.

Deodar is used for some kinds of pencils. Bombax Malabaricum which is called *Savar* in Bombay is available here in planks. Tons of planks can be bought in Bombay.

After planing a plank should measure $^{5}/_{32}'' \times 21'' \times 5''$. So one should buy such pieces of planks. One man can plane one gross planks in one day by hand. One plane is required which will make semi-circular grooves for leads in these planks. The carpenters have such planes to make a single groove but for this purpose a plane is required to make 16 grooves. These grooves must be straight and parallel to the sides.

TREATMENT OF GRAPHITE.

Pure graphite is mixed with clay and the mixture is ground as finely as possible. The quality of pencil depends on fineness. The proportion of clay and graphite varies according to the nature of pencil. Pencil becomes hard if more clay is used. For ordinary pencils 5 parts of graphite are mixed with 4 parts of clay. For hard pencils 5 to 5 parts are taken. This can be ground in stone mortars as are used by the Vaidyas. Water being expressed from the graphite, fine borax powder is mixed with it. In Bombay small pots are avail-

able, in which arrangement is made to get pressure by turning a screw handle. These pots are meant for preparing *Chakalas*. One can make use of them for forming threads of lead from prepared graphite balls. The bottom plate is perforated with a series of concentric holes of the diameter of the threads of lead to be drawn out. The vessel is given a charge of graphite over which is put another plate on which pressure is applied steadily as in a fly press. And so many threads of lead can be pressed at one time. The entire pot with the screw handle arrangement must be supported on a stand so that the threads may be collected with ease. They are then placed in required lengths on grooved plates for drying in the sun. After drying they are mixed with French chalk. Dried leads are put in big iron tubes. Interspaces are filled with graphite powder. Some spirit is poured in the tube to make the contents wet. Iron covers should be put on both ends and corners should be covered with wet clay. Baking changes the physical property of leads. After the clay is dry the tubes are placed in oven and heated till they are red-hot. Then the leads are put in molten wax and allowed to cool. After they are cool, wax is scraped from them.

PROCESS OF MANUFACTURE.

Grooves in planed planks are glued and the leads are placed in these grooves. After gluing one board is placed over the other and put under pressure. After they are dry round pencils are

to be prepared from them. Pencils are separated by thin small circular saw. These square pencils are rounded in a rounding machine. This can be done by hand also. The blade of a hand plane should be so constructed as to have semi-circular grooves in it. With this plane one can make such grooves on the glued planks as to make half round parts of pencils. Small grooves for leads as well as the rounding of the pencils can be done on planing machines. Or round cutters can be made which will give half-round forms to the pencils. But for small-scale industry only hand plane should be used.

POLISHING, STAMPING, ETC.

After the pencils are rounded they should be polished if not smooth. Now they should be coloured with oil colours or they should be kept plain if the colour of wood is good-looking. Now they are to be stamped with name and quality. For this purpose an engraved stamp in steel is required. If made of brass it will not last long. For this purpose small lever die embossing press should be used. In the place of the die the engraved punch in steel or brass should be put. After stamping the pencils should be packed.

After beginning this industry on a small scale one should slowly add one machine after another. After a few years this small industry will grow into a big factory.

ESTIMATE.

One man can plane one gross boards in a single day of eight hours. These boards will produce 24 gross pencils.

If he works for four days more he will be able to prepare these 24 gross pencils ready for sale. In one month he can prepare 144 gross pencils in all.

Cost of manufacture of 144 gross lead pencils follows:—

1.	Cost of 80 lbs. of graphite at Rs. 1/8 per lb.	Rs. 120
2.	Cost of 80 lbs. of clay at As. 3 per lb.	Rs. 15
3.	Cost of wood sufficient for so many pencils	Rs. 140
4.	Cost of Glue, colour, foil, etc.	Rs. 7
		Rs. 282

In framing this estimate labour and price of hand tools is not calculated. 144 gross pencils @ Rs. 3 per gross will bring Rs. 432. Deducting the cost of materials Rs. 282, the balance remains Rs. 150. If a family of 5 persons works on this manufacture, the income will multiply to five times while the cost of tools will remain the same.

The industry is worth trying on a small-scale. Supposing one is not able to prepare so many pencils in one month, still it will be profitable to take up this industry.

VI.

OZONE: ITS INDUSTRIAL PRODUCTION AND UTILISATION.

By S. KRISHNAMURTHY, B.Sc., (Hons.),

India Meteorological Department, Poona.

OZONE is what the chemist might call an allotropic modification of oxygen. Ordinary oxygen molecule is made up of two atoms of oxygen, whereas ozone is made up of three atoms of oxygen. This fundamental difference in their molecular structure is mirrored in their physical and chemical properties. Ozone is characterised by its extreme reactivity and instability as compared with its first cousin oxygen which is comparatively quiet and stable.

INDUSTRIAL APPLICATIONS OF OZONE.

The uses to which ozone could be put are many and varied. It is utilised as a reagent for purification, in surgical and therapeutic work, in bleaching, in paint and varnish industry, in fine chemical industries, in food preservation, etc., etc. These fields cover a vast area in human scientific activity. It shall be the aim of this article to show how intimately the industrial production and utilisation of ozone is bound up with other industries and naturally with human happiness and advancement.

ADVANTAGES OF THE DIFFERENT PROCESSES.

We shall consider which of these three methods is most suitable for India at the present war time. The chemical production method would involve a good deal of expense in preliminary research work, which expense the industrialist is wont to regard, of course erroneously, as a waste. So neglecting it for the moment, we can choose either the silent discharge method or the electrolytic method. Both these involve the expenditure of electrical energy, which could be purchased as industrial power at a cheap rate, if the Government would help the industry during the war time by securing the necessary cheap power. Since the silent electric discharge method has been thoroughly exploited, it is desirable that in India, we should start at this time the production of ozone by the electrolytic method. War has given great impetus to many new industries and once we set on foot the ozone industry now, it would grow into a gigantic industry which would not only pay for its existence, but would earn increasing profits for the industrialist.

USES OF OZONE.

We shall now pass on to briefly consider the several uses of ozone. First of all we shall deal with those uses which are likely to be most beneficial during the war and next we shall mention the other general uses to which it could be put during any time, peace or war.

It is quite essential, that in an industrially backward country like India, the first thing to do is to establish the ozone industry which being the precursor of other industries will bring in its train other industries and thus contribute to our industrial prosperity.

It is impossible to give anything more than a brief account of this problem. If any one should find in this article something to take up seriously, the writer will be only too happy to supply him with exhaustive methods of procedure and suggestions regarding the actual processes of manufacture and utilisation of ozone.

TECHNICAL PRODUCTION OF OZONE.

We shall first deal with the methods of production of ozone. The economics of the process should be the deciding factor. We shall deal with three methods of production and compare the efficiency of each process.

CHEMICAL PRODUCTION.

The chemical production of ozone on a large scale has not met with much success. The subject offers a fertile field for industrial research and offers infinite possibilities for industrial exploitation. But scientific investigations should be continued with systematic painstaking research directed by an intellect of the first order for at least 3 months. We shall briefly see what the method is and wherein it offers scope for development in India.

The celebrated French chemist Moissan in his classical researches on Fluorine which he isolated by the electrolysis of fused potassium hydrogen fluoride, noted that appreciable quantities of ozone were produced when a few drops of water were introduced into an atmosphere of fluorine, the formation of ozone proceeding according to the equation:—

$$3\ F_2 + 3\ H_2O = 6\ HF + O_3.$$

This is especially marked at low temperatures, when the rate of thermal decomposition of any ozone formed is considerably reduced. An ozone content of upwards 14 % in the oxygen disengaged by means of this reaction may be obtained at 0°C. Though the cost may be comparatively high, considering the large concentrations of ozone one can get, the chemical method is preferable to the others and offers hope of technical application.

ELECTROLYTIC PRODUCTION.

Early in the 19th century Cruickshank noticed the fact that electrolytic oxygen, generated by the electrolysis of dilute sulphuric acid at insoluble anodes frequently contained ozone. Berthelot observed the formation of both ozone and hydrogen peroxide in sulphuric acid and other electrolytes and that high anodic current densities were essential for the production of ozone.

With the introduction of the ionic theory by Arrhenius and Van't Hoff in 1887, the anodic reactions taking place during the electrolysis of dilute sulphuric acid were systematically studied. It emerged from these investigations and Nernst's

brilliant conception of electrode solution pressure, that a method could be evolved for determining the influence of the anode potential on the discharge of anions without having to take into account any cathodic reaction.

Theoretical calculations from the oxygen-ozone cell show that an extremely high anode potential is required to remove the formation of ozone, while in order to ensure its stability when produced both electrode and electrolyte must be kept cold. Fischer and others used a small platinum tube 6 millimetres long which was sealed to two terminal glass tubes and served as anode; the tube itself was covered with glass with only a thin strip 0.4 mm wide, exposed to the electrolyte. Cold water was circulated through this anode, and the electrolyte was kept cold by immersion.

Using an anodic current density of 58 amperes per sq. cm. and a sulphuric acid concentration of density 1.075 to 1.1, a yield of 17 % by weight (11.3 % by volume) was obtained in the anodic oxygen. By using a glass covered rhomboidal, platinum tube and one edge 0.1 mm in width being exposed by grinding away the glass, the tube (length 11.5 mm.) was maintained at —14°C by circulation of a solution of calcium chloride, a yield of 28 % ozone was obtained. The optimum concentration of sulphuric acid lay between 1.075 and 1.1. The quantity of ozone produced per kilowatt hour rose steadily with continued use of the platinum.

A yield of 7.1 gms per kilowatt hour was obtained at a potential difference of 7.5 volts

and an anodic current density of 80 amperes per sq. cm. If we calculate the theoretical production of ozone from its heat of formation, 34,000 calories, the yield of 7.1 gms. indicates an electrical efficiency of $\frac{7.1}{12000} = .6$ per cent.

When operating at high current densities anodic polarisation considerably depresses the yield of ozone. So increased yield of ozone could be obtained if anodic polarisation could be diminished without alteration of the anodic current density, since the secondary oxidation of ozone would be diminished. A series of experiments were carried out in which an alternating current was superimposed in the direct current flowing through the cell, while a direct and alternating current of variable periodicity was applied simultaneously to the cell. It was established that the optimum acid density varies with the area of the electrode and not only with the current density, more concentrated electrolytes being desirable for big electrodes. The yield of ozone was also affected by the periodicity of the current. The optimum yield was obtained under the following conditions :—

Electrode area 0.333 sq. cm.; Periodicity 18 v. per sec.; Temp. 10°C; Acid density 1.478.

Direct Current	.25 amperes
Alternating Current	1.25 „
A.C./D.C.	6
Anode Current Density	0.75

Percentage of O_3 by volume calculated on the direct current	37

The most important point from a *technical point of view* was the effect of the alternating current on the potential difference necessary to effect the passage of this current. From the above data the production of ozone per kilowatt hour works out to :—

96,540 couloumbs or 26.8 ampere hours liberate one gram equivalent or 11.2 litres of oxygen gas. Under the conditions of the experiment however, the liberated gas contains 37 % of ozone which would result from the condensation of 55 % of oxygen which weighs 4.4 gms.

Hence 26.8 ampere hrs. liberate 4.4 gms. of ozone. The potential difference which has to be applied to the cell to effect this liberation is 2.75 volts. Thus 4.4. gms. of ozone are produced by expenditure of energy equal to 26.8 × 2.75 or 73.7 watt hours representing an output of 59 gms. per kilowatt hour. This yield approximates to those obtained by the method of " silent" electric discharge to be dealt with below.

It is quite likely that if larger electrodes and a cooled electrolyte were employed, this method could be developed for the technical production of ozone both for strong and weak gas concentrations.

PRODUCTION BY SILENT ELECTRIC DISCHARGE.

The formation of ozone by the action of the silent discharge on air is the only process of ozone production which has received considerable tech-

nical development and many ozonisers have come into use for the economic manufacture of ozone and ozonised air.

Since the technical production of ozone by the silent electric discharge has received considerable attention from the chemist and the industrialist, the likelihood of materially and appreciably increasing the yield by this method or of producing ozone on a more economic scale is very remote. So we shall just make mention of the process.

Industrial ozonisers may be grouped into two distinct types: (i) those in which the silent discharge passes across the air-gap without the interposition of any solid dielectric and (ii) those in which one or both of the electrodes are protected by some suitable dielectric material usually glass.

About the best ozoniser is that of the Ozonair Company. This ozoniser is extremely simple in construction and efficient in operation. The electrodic discharge through the glass dielectric plates and airgap is facilitated by employing flat sheets of metallic aluminium alloy gauze as electrode material; this possesses the dual advantage of an even distribution of points over the whole electrode area, and of being practically resistant to corrosion or tarnishing.

Cooling is effected by the air current and concentrations upto 3 or even 4 grams of ozone per cubic metre may be obtained. The operating voltage is usually 5000 at periodicities varying from 25 to 100. Tests have shown that at a concentration of 2 grams per cubic metre, the output may exceed 100 grams per kilowatt hour.

(i) SURGICAL AND THERAPEUTIC USES.

During the last war portable ozonisers were in use in many military hospitals, for the treatment of wounds. Major Stokes of the Queen Alexandra Military Hospital (Lancet 1918) describes the following method of wound sterilisation which appears to have given excellent results. Wounds and sinuses are washed twice daily with boiled water and a dressing of oxy-gauze is applied. The ozone (ozonised air) is applied on the wound surface or on to the cavities and sinuses twice daily for a maximum time of fifteen minutes or until the surface becomes glazed. At first ozone causes an increase of the discharge of pus which is gradually replaced by clear serum. The serum at a still later stage becomes coloured reddish or purplish. Ozonised air applied in this way was a strong stimulant and increased the flow of blood to the affected part and was a germicide and exerted great powers in the formation of oxy-haemoglobin. A record of 70 cases so treated is given, in which the period of treatment varied from a few days to 3 months and was in practically all cases completely successful.

Curle (*Practitioner* 864, 1912) describes the application of ozonised air to the liberation of iodine in the lungs for the treatment of phthisis. Potassium iodide is introduced into the lungs by ionisation and the iodine is subsequently liberated by the inhalation of ozonised air. In case of entiritis and dysentry, for disinfection of the intestinal canal, Lessing (Lancet Nov. 1913) records the improvement obtained by washing out

the intestinal canal with ozonised water. The treatment of ulcers and pyorrhoea of the teeth has been successfully accomplished with ozonised air.

The action of dilute ozonised air in stimulating the production of oxy-haemoglobin has been successfully utilised for the treatment of cases of anaemia, whilst its application in cases where there is a shortage of oxygen absorbed in the system, such as in asthma or heart weakness, is not without benefit.

(*ii*) *IN BREWING AND FOOD PRESERVATION.*

Ozonised air has found increasing application in brewery, to prevent the ingress of adventitious micro-organisms not only during the process of fermentation and cooling of the wort, but also during refrigerating and bottling the beer. It was found that aeration with ozonised air containing 3 grams per cubic metre at the rate of 12 cubic metres per kilogram of compressed yeast for a period of 15 to 20 minutes ensured the production of normal and energetic fermentation. The flavour of the beer was unchanged, its keeping qualities improved, together with its power of resisting infection on storage.

A useful field for the application of ozonised oil is to be found in the preservation of food, especially in connection with refrigeration. For the prolonged storage of fresh meat, it is necessary to maintain it at a low temperature in order to lower the rate of hydrolysis both proteoclastic and lipoclastic produced in the meat by the naturally

occurring enzyme. During storage and transit not only are the substances subjected to internal attack by natural enzymes, but frequently external sources of contamination are to be found, especially flies and air-borne micro-organisms. Thus maintaining perishable food-stuffs at a low temperature in a sterile atmosphere, ideal conditions for preservation obtain. Several large refrigerating warehouses and shipholds have been equipped with ozonisers on the air circulating systems.

It is significant to note, that enhanced efficiency of ozonisers is secured at low temperatures and hence the conjunction of an ozoniser in a refrigerating system is a particularly economic installation.

(*iii*) *APPLICATION TO HYGIENIC PURPOSES.*

The sterlisation of water by Ozone—Even dilute ozonised air would effect the sterlisation of polluted water, provided intimate contact between gas and liquid was effected. Ozone energetically attacked bacteria in water from which any excess of inorganic matter has been previously removed. Chemically ozone is the ideal agent for purification, since it leaves behind nothing foreign in the treated water, with the exception of oxygen which assists in the normal aeration and greatly augments the palatability of water.

The firm of Siemens and Halske developed the process of sterlisation with ozone and large plants were installed at Weisbaden and later at Paris and Petrograd. The important problem is to ensure intimate contact of every drop of water

with the ozone. In the first plants of Tindal and Frise both ozonised air and raw water entered by separate pipes at the base and flowed in the same direction through a flint-packed tower which was divided into segments by means of perforated metal or celluloid plates.

A considerable advance on this practice was made by Cetto by the introduction of an emulsifier for ensuring intimate mixture of ozonised air and water at the base of the tower. The emulsifier is constructed on the lines of a simple water vacuum pump, the water supplied under pressure drawing ozonised air under vacuum. In addition to securing intimate mixing, utilisation of the vacuum produced by water stream, the necessity for pumping ozonised air by special pump is avoided.

The greatest economy in the utilisation of ozone was effected by deFrise who introduced a cylic system in the plant. The ozone compressor draws the ozonised air from the ozonisers and forces it into the plate sterilising tower ; from the top of the steriliser, the air returns to the ozonisers, passing in its way through a separator and drier in which it comes in contact with calcium chloride. A small suction valve on the inlet of the separator admits fresh air to make up for the loss through absorption by sterilised water. The sterilising tower is constructed in the sectional system, being built of enamelled iron sections 20" long and 3 feet in diameter, each section (there being thirty sections in the tower) being separated from the others by perforated plates.

Since inert organic meter is readily oxidised by ozone to carbon dioxide and water, in order to exercise every possible economy in the utilisation of ozone, it is necessary to subject polluted water to some preliminary purification like filtration and sedimentation.

Purification of air—Several types of apparatus have been designed for the purification of air in confined spaces, as theatres, lecture halls, slaughter houses, tanneries and breweries, whilst extended use of ozonised air has been made upon the Central London Railway systems and public lavatories. The installation on the Central London Railway was so successful in operation that the system of ventilation has been extended to practically every other London tube. Why not adopt the system in India to especially the filthy 3rd class compartments in the Indian Railways ?

(*iv*) *IN FINE CHEMICAL INDUSTRIES.*

The oxidation of organic substances by ozone has been the subject of numerous investigations. Ozone is finding many applications as an oxidising agent in the fine chemical industries—for the preparation of several synthetic perfumes as vanillin, pipermal and anisaldehyde, the manufacture of vanillin being accomplished on a very large scale, from eugenol in France, America and Great Britain.

For analytical purposes in organic chemistry ozone is very useful, since by the preparation of ozonides and their subsequent decomposition, the structure of various complex compounds containing ethylenic linkages has been elucidated.

(v) *OTHER USES.*

The applications of the uses of ozone in the oil, fat and wax industries are very considerable, the reagent being used for a great diversity of purposes, e.g.—

(a) Removal of odour, flavour and colour from oils and fats intended for edible purposes.

(b) Bleaching and refining oils and fats for use in soap industry.

(c) Bleaching of oils for paint and varnish making.

(d) Bleaching and refining of waxes for use in the manufacture of candles, polishes and ointments.

The application of ozonised air to *conditioning textiles* is stated to be entirely successful.

A particularly fruitful field in India is the *drying of copra.* Copra when subjected to the ordinary sun drying processes is liable to acquire an exceedingly offensive smell. Useful application of ozone could be made here. The conditioning of air in flour mills by means of ozonised air is said to be attended with a possible increase in the mill capacity of 30% and the practical elimination of the flour moth.

Enough has been said of the innumerable uses to which ozone could be put. In an industrially backward country like India, the paramount importance of the industrial production and utilisation can hardly be over-estimated. In the short scope of this article, it has been possible to give only an outline of the problem.

VII

PROCEDURE OF MASS PRODUCTION OF FANS, METERS & TRANSFORMERS

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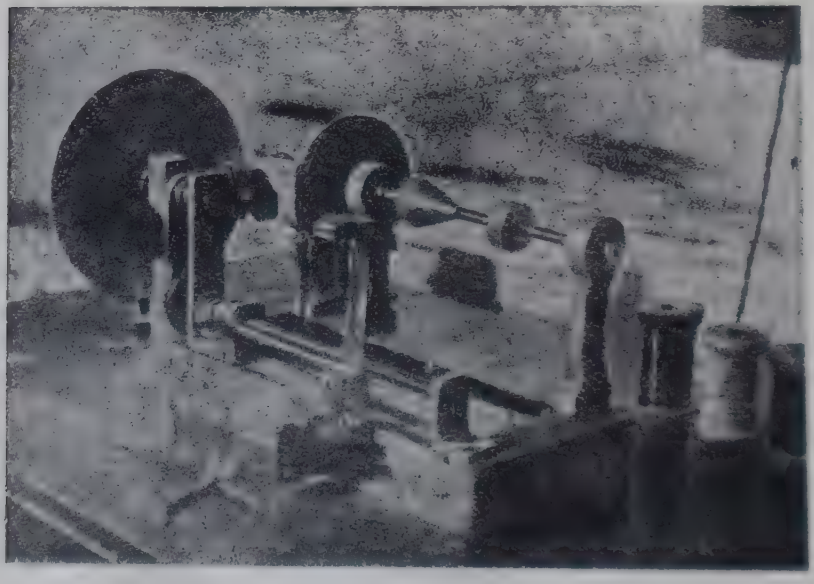
THE so-called hand-made articles may in some cases be superior to those produced by machines for large scale production, provided the production staff is a selected one.

WINDING MACHINE.

Take the case of a Eureka resistance element in which very fine wire, e.g., 42 S.W.G. bare is to be wound on an ebonite or other insulating rod. The hand process for winding such a resistance is very tedious and unless and until a very good device is applied, it is practically impossible to rewind it. A very good device once applied by the author is to take two wires of the same size from two different bobbins and wind the thing with both of them without giving any twist, pushing the newly wound portion towards the end by the left hand thumb, so that the gaps are delicately filled, and unwinding one of it so that a uniform and equal space be left between the adjacent turns of the winding. The mechanical system is simpler and gives a comparatively more uniform tensile stress over the metal. An idea of the machines for giving such windings can be gathered from an experiment performed with a

simple lathe having automatic sliding and screw cutting arrangement. The insulating rod of ebonite or other material is fitted in a through chuck which is also called a self-centering chuck, so that it may revolve in centre. The gears are so arranged that the sum of the gap between the adjacent turns and the diameter of the wire is equal to the pitch of the thread. The slide race is put on the screw rod and a wood piece is fitted on the tool post and a slot is cut in it so that it may guide the wire winding on the rod. After fixing one end of the wire on the rod, machine is switched on and it will be seen that within a few seconds the winding is complete. A machine suitable for this purpose having variable sliding motions to suit different sizes of wires and different gaps between adjacent turns is shown in the figure which was designed by the author for



A Typical Winding Machine.

laboratory use in 1939. This machine was also used for making field coils, electromagnet and small transformer coils, induction coils and other similar coils requiring wire of from 45 S.W.G. bare to 16 S.W.G. double cotton covered.

CONSTRUCTION OF MOTORS, ETC.

Now let us come to a fractional horse power motor or fan. The simplest case is of a squirrel cage induction motor. It requires less complicated machines and is mostly used in fans on account of great popularity of A. C. in distribution system. By dividing it in parts we see that the main part of this motor is the cast iron body, the second is the two covers on both the ends and third is the laminated stator; the fourth being the rotor and fifth the shaft and lastly the bearings in which the shaft revolves.

The simplest method of casting the body and the covers is the sand core moulds and the cupola furnace system and although even in foreign countries the system is mostly popular the author prefers another system given below :—

INDUCTION FURNACE & MOULD.

Low frequency induction furnace must be used for melting purposes and the moulds preferred are the permanent mould made of cast iron. In the advanced foundries cast iron permanent mould castings are being made in increasingly large quantities in the cast iron moulds. The secret of the success of permanent moulds for cast iron lies in coating the moulds with special materials. The importance of permanent moulds

for cast iron is obvious; it gives pure material with structure without holes; it is comparatively more accurate in size. But the biggest advantage is the saving of time required for preparing the otherwise sand moulds, drying them and putting them to other treatment before using. The advantages in favour of the system preferred are: (1) Greater and more accurate control over the work; (2) Less space required for foundry shop; (3) Neat and clean work : (4) Very great saving of time ; (5) Better castings produced, and so on.

Now the question arises in connection with the availability of the electric furnace, and in fact it is not so easy to get one to-day at any cost. But then at the same time it is not impossible to make one locally. The frequency changing can be done by a rotary frequency changer or simply be arranging supply from the terminals of a wound rotor when it is run by another motor at a speed lower than its calculated synchronous speed. The laminated iron core can be made by using thin mica sheets instead of papers, and further cooling of the primary coil and the core can be done by circulating cold water in a proper way. The special type of crucible has always been a problem with this type of furnace and the author suggests mica crucible for occasions of emergency.

STATOR CORE.

The stator core is one of the most important and one of the most difficult works in manufacturing A.C. motors. It is made up of punched sheets of steel or ferrous alloys which give greater permiability at lower ampere turns, lower eddy

current and hysterisis losses and lower shear resistance. There are many compositions of nickel, cobalt and silicon, etc. in the market by the name of permalloy and others but unfortunately now-a-days none of them is available. Powdered iron ground to pass a 100—200 mesh screen, rolled with flake zinc which is afterwards removed, insulated with shellac and compressed to 100 tons per square inch to produce blocks nearly as dense as iron and with a tensile srength of $\frac{1}{4}$ to $\frac{1}{2}$ tons per sq. in. is also used in America and other countries to give the lowest eddy current and hysterisis losses. However, mild steel sheet of soft quality can be very well used at present and it has been found that after annealing, the properties improve remarkably. So after cutting the sheets in power punches they are annealed in a resistance furnace. The power punches may be of the ordinary type but the dies and punches are required to be of tungsten steel and the secret of the long life of the punches lies in the process of hardening them by special process. Unfortunately the tungsten steel is also scarce now-a-days and manufacturers are compelled to use carbon steel. Great accuracy is required in making the dies and punches and the line block process system of marking the surface is preferred for the high class accuracy. The steel tip thoroughly annealed and filed to give polish surface is coated with sensitive emulsion in the dark and the negative prepared from the accurate drawings in black and white, is placed over it and the whole thing is exposed to the sun for about 15 minutes; the sensitive mate-

rial is treated under chemicals and the proce violet colour is painted over the surface so th the impressions develop over the metal. Both t die piece and the punch piece are treated sim larly and by cutting off the white or the bla portion the die piece or punch piece can be obtai ed at will. The colour of the die after tempering important and can be noted after a short trial.

THE ROTOR AND THE SHAFT.

The rotor and the shaft is the revolving pa and care should be taken to make it proper balanced after putting the squirrel cage, so th the vibrations may be minimised at high speed The rotor sheets are also punched in the sam way as stator sheets and require less care annealing. Also there is no need of laminati the same as the slip frequency is very very lo The shaft may be of mild steel, case hardened the ammonia process, where bearings are to run

BEARINGS.

Lastly come the bearings which should either ball or of low friction metal. Bronze the most popular metal for bearing purpose a there are so many compositions in the mark that selection becomes difficult. The auth recommends a so called lead-bronze having a co position of 70-28-2 which can be locally made a which has very good machining property—an a vantage in mass production. For mass producti the old process of casting the metal in the shap of rods and then turning on lathe is not preferr A better method is to die cast the bearing or

ast cast it in a cast iron permanent mould and the end bring it to size on capstan by fixed ternal reamer and outside cutter. The greatest dvantage with this method is the saving of time nd producing the component parts of highly ccurate size. There is also less wastage of the etal due to there being less turnings. It can also e arranged that the turnings may drop over a me-tanical conveyor and just carry them to the elec-ric furnace where after passing over a magnet ulley the whole thing can be remelted.

DRILLING AND FITTING.

While machining the cast iron parts of the ody, care is to be taken in making screw holes. t is never advisable to make one hole at a time with an ordinary drill machine. A special drill machine have as many drill bits fitted to it, as the number of holes are required. The turned cover is placed in an accurate seat provided for the pur-pose and all the holes made at the same time. Special drill bits and an extra attachment working as a guide for the drill bit will be needed to ensure proper position of the holes.

Of course on the other side of the workshop the duly annealed and shellac coated sheets are being received by a fitter having his bench at the terminus of the conveyor carrying them. The fitters' work is to take the required number at a time and after putting them in a hand press to make the rivets. The assembled core is passed on from his bench to the winding bench where ready made coils properly taped, varnished and baked

are already being received from the coil shop. The coil shop may comprise of three or four coil winding machines having turn counters attached to each machine, one or two taping machines, one baking and varnishing room and lastly a small test bench to see the ohmic resistance of the coil.

Coming back to the production shop we find the stator electrically completed and being sent to the general assembling bench through conveyor provided for the purpose. The general assembling bench comprises of four or five seats having a terminus of conveyor on each seat where the part is thoroughly inspected and passed on to the fitter who will just fit another part to it and then pass on to the third, in this way continuously passing on the parts after finishing their jobs. In the end we find the completed motor ready for test.

TESTING AND FINISHING.

The test room comprises of a fluctuating light type speed indicator, a wattmeter and cosϕ meter panel, a temperature measuring apparatus, prony brake, a vibration detecting apparatus and so on. But all the tests are not required to be made on all motors. The less important ones are necessary only for every fifth or sixth.

Another important part is the name plate which attracts the layman first. Many manufacturing firms are making the name plate by manual engraving method while others are buying ready made from the name plate making firms. But in fact it is not at all difficult to arrange to make them locally over brass, copper, zinc and aluminium by the process of line block.

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